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ABSTRACT

The purpose of this study was to determine if five-year-old children displaying high or low ability to process visual information exhibited the same high-low ability in proficiency of motor tasks which were dependent upon visual information for successful completion. The subjects were 40 five-year-old children who were required to pass a visual acuity screening test. The children were assigned to a high or low group for each of six factors: (1) vision; (2) stationary striking of a ball; (3) moving striking; (4) aerial catching; (5) bounce catching from five feet; and (6) bounce catching from ten feet. It was concluded that no significant relationship existed between visual processes and motor tasks requiring vision for successful completion. A significant difference was found between high-low bounce catch from ten feet on the various visual tasks. The high group performed significantly better on the vision tasks than the low group. It is concluded that this is because this task required a perceptual sophistication not required by the others. (JD)

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THE RELATIONSHIP BETWEEN VISUAL INFORMATION PROCESSING AND MOTOR PROFICIENCY IN FIVE-YEAR-OLD CHILDREN

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A thesis submitted to the
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by

Sandra K. Skovran

August, 1977

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SKOVRAN, SANDRA K., M.A., August, 1977 PHYSICAL EDUCATION

THE RELATIONSHIP BETWEEN VISUAL INFORMATION PROCESSING AND MOTOR PROFICIENCY IN FIVE-YEAR-OLD CHILDREN

Director of Thesis: Karen L. DeOreo

The purpose of this study was to determine if five-year-old children displaying high or low ability to process visual information exhibited the same high-low ability in proficiency of motor tasks which were dependent upon visual information for successful completion. 40 children were tested on visual and motor tasks. The visual tasks included three subtests from the Illinois Test of Psycholinguistic Abilities and Ayres' Figure Ground Test. The motor tasks included five ball-catch tasks, four aerial catching tasks, two stationary striking tasks, four moving striking tasks, and a visual motor sequential memory task. Data analyses consisted of a principal component factor analysis, conducted to identify common factors and reduce the dependent variable list. The identified factors were: I. Vision; II. Stationary Striking; III. Moving Striking; IV. Aerial Catching; V. Bounce Catching Five; and, VI. Bounce Catching Ten. Using the identified factors and their components, the children were assigned to a high or low group for each of the six factors. A series of MANOVAs and Discriminant Function Analyses were conducted to determine significant

differences between high-low groups. It was concluded that no significant relationship existed between visual processes (as measured by the ITPA) and motor tasks requiring vision for successful completion. The high vision group did not necessarily perform better on the motor tasks. A significant difference ($F = 4.17$, p .01) was found between high-low Bounce Catch Ten Groups on the various visual tasks. The high Bounce Catch Ten Group performed significantly better on the vision tasks than the low group. The Bounce Catch Ten task required a perceptual sophistication not required by the other tasks.

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CHAPTER I

INTRODUCTION

While in the process of teaching young children simple motor tasks, it was observed by the experimenter that some children proficiently performed the task immediately after observing it while others, even after repeated observation, could not perform the task. It appeared that those who could not perform the task lacked understanding of how to begin the movement. Thus, the experimenter's curiosity heightened when confronted with the child's ability to understand and interpret what is seen (visual information processing). Was the same information seen by all children? Did the children who immediately and accurately performed the motor task "see" more than the children who could not perform? Exactly what was the role of vision in successful or unsuccessful motor performance?

Ultimately, this interest in the role of vision in motor performance resulted in the design of this study and sought to answer the following questions:

1. What is the relationship between visual information processing and motor proficiency?
2. Do those children who efficiently process visual information perform better on motor tasks requiring visual information for success-

ful completion?

Perception and Its Development

Perception " ... is the central portion of the situation - interpretation - action chain, leading to purposeful motor activity" (Cratty, p. 75). Sensory information or input, past events, and physiological changes each act upon and form perception. As a human organism grows and develops, the perceptual as well as the physical systems are affected. This growth and development is due to an increase not only in neuromuscular complexity, but also in the capacity to explore and act upon the environment. It is this "exploring" and "acting upon" that is of primary concern here. In order to "explore" and ultimately "act upon," the child must take in information from the environment. There is only one way that this can be accomplished and that is through the sensory systems of the body (vision, audition, gustatory, olfactory, tactile-kinesthetic). There is no other way the human organism can gain knowledge about his physical world. This taking in and acting upon environmental information is called sensory information processing. To consequently "act upon" the environment requires the use of movement. It is conceivable that one could remain stationary and still "act upon" the environment, but the ultimate effect would be extremely limited. Movement is such an innate consequence of sensory informa-

tion taken in that the process is seldom questionned.

Williams (1973) called attention to four primary phases of sensory information processing as applied to the visual system. In Phase I, Information Pick-up, the visual receptors record information about position, speed, and direction of the image. Information from nearby environmental images is blocked out as one selectively attends to only necessary information. In Phase II, Integration of the Stimulus Information, the visual information is relayed to analytic centers which are concurrently receiving specific information from the other sensory systems of the body. Although some information is lost at this point, an efficient short-term memory will retain an abundance of sensory information received.

In Phase III, Higher Order Analysis of Stimulus Information, three processes occur. The first, which is sensory synthesis, involves the comparison and analysis of sensory information from the past and present. The final interpretation of incoming information is made here. The second process involves long term memory storage which serves as a library, so to speak, containing frames of reference from previous sensory information. Knowledge about new information is compared to stored information from previous experiences during this process. The final process is the comparator whose job it is to "update" concurrent changes in the various sensory modalities. It constantly monitors

sensory input and enhances final decision making. The fourth and final stage is storage. Once a final decision has been made, the information is placed in long term memory for future reference.

Visual Perception and Its Development

> We are born with the ability to see, but we must learn to understand what we are seeing. The understanding of what is seen is referred to as visual perception.
> (Medvedeff, p. 1)

Just as the ears do not pick up all of the sound waves, the eyes do not pick up all of the visual waves. The eyes are organs of a special sense for two reasons: First, the stimuli or cues come from outside the body; and second, these stimuli are received by special cells called receptors which are located inside the cranium.

Performing one of the most complex functions in vision is the retina. The retina contains two types of specialized cells called rods and cones which are so named because of their shape. These specialized cells are located deep within the cranium, away from the source of light and have the fascinating ability to change a light stimulus into the necessary electrical activity utilized by the central nervous system to perpetuate a neural impulse.

The least amount of light entering the eye before sight is stimulated is called the stimulus threshold. Once this threshold is reached, the process of converting

light energy into electrical energy occurs as follows: When the beam of light enters the eye through the pupil, it first passes through the cornea where refraction begins. Refraction enables clear images to be produced on the retina and occurs because of the change in speed of light as it penetrates substances of different densities. The light then passes through the aqueous humor and into the inner eye. Further refraction takes place in the lens, allowing more complete focusing of the light which then goes to the rod and cone. Two pigments, rhodopsin (located in the rods) and iodopsin (located in the cones) are responsible for the conversion of light to an electrical impulse. When light enters the retina, the membranes of these pigments are excited, thus creating a chemical change which ultimately produces the electrical impulse. After absorbing light energy, rhodopsin is bleached and converted to lumirhodopsin which has a great amount of free energy. The unstable nature of lumirhodopsin causes it to decompose into another unstable compound called metarhodopsin. This immediately splits into retinene and scotopsin. It is during this changing process that rhodopsin creates electrical currents which innervate nerve impulses at the rod-cone connection. How this actually occurs is still not known. Once the decomposition of rhodopsin forms nerve impulses, retinene and scotopsin combine to reform rhosopsin. Light intensity and amount of rhodopsin affect the

speed of this process.

The vitreous humor absorbs some of the photons from the beam and after the rods and cones transform the light into electrical impulses, they are sent via the optic nerve to the visual cortex of the brain. The visual cortex serves several functions. The cortex records changes in light intensities by discriminating light and dark. It also is able to record patterns such as dots, circles, and lines, as well as to distinguish the boundary lines and contours of objects. The cortex also records object movement and color.

Hierarchical Organization of Visual Perceptual Development

Melamed (1976) interprets visual perception as a process of extracting information from the environment. Before a stimulus can be perceived, light wavelengths must fall between 400 and 700 billionths of a meter. When a wavelength falls within this range, the eyes are stimulated and sensory transduction occurs. This is a process by which the visual stimulus is translated into electrical energy for the nervous system.

Melamed proposes a hierarchy for visual perception with innate or unlearned abilities forming the base. Acuity is an example of this innate ability. An infant must "see" light before perception can take place. Through growth and development, environmental interactions, and

sensory stimulation, the infant is able to modify his innate abilities. This modification leads to the facilitation of his ability to adapt to, interpret, understand, and eventually manipulate his environment.

In the hierarchy, Melamed highlights the relationship between perception, learning, and thinking. He views perception as being the "superset" while learning, thinking, and memory subserve perception and act as "subsets." Perception involves extracting information from the environment. Learning deals with the utilization of past experiences for a more sophisticated process of information extraction with that information being stored in memory. Thinking rests on problem solving which is based on memory information.

When a problem is solved with readily available information, then the ultimate solution is easy. However, when the problem involves more detailed and/or abstract information, the utilization of concepts becomes important and information processing time increases. Problem solving abilities are facilitated by efficient and effective utilization of concepts.

To summarize: An infant is born with certain innate abilities which enable sensory stimulation to occur. Through maturation and LEARNING, more information is extracted from the environment by the sensory system and previously perceived information is modified. Thinking

and learning snowball, causing more efficient and detailed information retrieval and extraction with concept formation and abstraction being the ultimate result.

> ... as the perceptual set is broadened and becomes more complex and richly patterned with experience, the individual becomes capable of extracting more information from the environment. The process starts with simple reflexive action at birth and grows through maturation and learning to produce more powerful sets, which are mediated by concepts, hence, thinking becomes more expert.
> (Melamed, p. 3)

Thus, when viewing visual perception as a hierarchy, the process is divided into the following stages: 1) The eyes are stimulated by light; 2) The object, because of its brightness, location, and structure, is detected from its background; 3) Through more detailed information, a more accurate picture of the object is perceived; 4) The object is recognized and identified; and, 5) The information is used to adapt behavior and act upon the environment.

Quality of Information Processing

Many criteria affect the quality of information processing. Children lose incoming information much faster than adults although they pick up the same amount of information. Between one and five seconds of information intake, a child will lose sixty percent or more of that information (Williams, 1973). Adults attend to only task-

relevant information while children take in irrelevant as well as relevant information, thereby overloading the system and promoting information loss.

Sheingold (1973), who studied five-year-old children, found that children can take in as much information (tachistoscopically) as adults but will lose more information than adults. Sheingold attributes the ability of adults to retain information to more efficient encoding strategies. That children do indeed possess inefficient rehearsal and encoding strategies has been pointed out by Gottschalk et. al. (1964) and Haith et. al. (1970). Rehearsal strategies are those that provide the perceptual system with the ability to hold information in short-term memory for a brief period of time. Encoding strategies, on the other hand, allow the child to classify common information into "chunks" and then to store these chunks in long-term memory for future reference. Gottschalk, Bryden, and Rabinovitch (1964) and Piaget and Inhelder (1956) agree that five-year-olds who excel in sequencing abilities do so because of efficient labeling strategies from which information can be recalled. When a child can organize his information, labeling as well as performance is enhanced.

Haith, Morrison, Sheingold, and Mindes (1970) compared the abilities of five-year-olds and adults in processing visual information. A definite limitation in the short-term memory of children was found, with possible

causes stated as inefficient encoding strategies, a fading of the image trace, or simply an inability to perceive the visual information.

Younger children are also unable to efficiently process multisensory information obtained through more than one sense modality - for instance, seeing and touching. Adults, by virtue of just living longer, are more effective at this process. Gibson and Yonas (1966) studied visual search behavior in elementary school children: second, fourth, and sixth graders as well as college sophomores. Results indicated that adults would process information more quickly and more efficiently than children.

Fantz (1966) upholds a different aspect of perception, believing that perception is duo-dimensional, involving localization (where is the object) and discrimination (what is the object). Adults can locate and discriminate objects at the same time and do so automatically. Children, however, and especially infants, have a naive and often obscure ability to locate. Development of localization is gradual. Because of this, the process of perception is different for young children and infants. For them, perception is the proficiency in hand-eye and visual-motor coordination. In adults, then, perception is the ability to locate and discriminate.

Aaron (1972) attempted to identify former experiences which would possibly enhance the perceptual learning of

children. These experiences, called epigenetic factors, were identified as the following: 1) Integration, or the ability to combine single units into a whole; 2) Directionality, or the ability to encode information from utilizing directional cues; 3) Redundancy, or the ability to perceive similarities; and, 4) Inhibition, or the ability to attend to only relevant information. According to Aaron (1972), these factors are the ones which enable a child to perceive and understand more as his perceptual system develops.

Statement of the Problem

The purpose of this study was to determine if five-year-old children, displaying high or low ability to process visual information, exhibited the same high-low ability in proficiency of motor tasks which were dependent upon visual information for successful completion.

Limitations

Limitations in this study included the following factors:

1. Selection of the subjects and schools was based on choosing nurseries in relatively close proximity to Kent State University. Statistical random selection was not conducted.
2. The speed of a pitched ball was not mechanically con-

trolled. It was believed, however, that a person could learn to pitch the ball at relatively consistent speed.

3. The release of the pitched ball was not mechanically controlled. It was believed that a person could learn to release the ball at relatively consistent angle, arch, etc.
4. One of the nursery schools included perceptual training in their curriculum, thereby possibly biasing the results.

CHAPTER II

REVIEW OF LITERATURE

The purpose of this study was to determine if five-year-old children displaying high or low ability in processing visual information exhibited the same high-low ability in proficiency of motor tasks which were dependent upon visual information for successful completion.

The review of literature includes two areas: 1) Visual cues and motor learning; and, 2) Visual perception and motor proficiency. A summary which concludes each section attempts to integrate common information from the various studies.

Visual cues and Motor learning

Research in motor learning has established the importance of vision in movement. General conclusions seem to be that visual cues rather than auditory or haptic cues, or any combination of the three, were basic to learning a motor task.

While the majority of research in this area studied visual processes in adults, Melcher (1934) was one of the first researchers to study children. She attempted to determine the effectiveness of visual and tactual cues in the process of learning a motor task. It was hypothesized

that if, in performing a task, the response organ needed tactual stimulation, then one of two possibilities would be occurring: 1) That visual and tactile perception developed because of tactile manipulation; or, 2) That visual and tactile perception were independent, with any interaction due to necessary and simultaneous utilization of the two while moving or learning.

Melcher (1934) noted that an assumption had often been made by researchers that children initially relied on kinesthetic dominance in the responding organ and as they matured gradually shifted this dominance to the visual system. With this in mind, Melcher (1934) studied 21 children who were 35-57 months of age. Each child was placed in one of three groups, which utilized one of three cues: 1) visual cues; 2) manual cues; or, 3) visual and manual cues. After watching the path of a stylus as it travelled through a maze, the children were asked to guide the stylus using the appropriate cue. Results indicated that children utilizing visual cues alone learned faster than those utilizing manual cues or a combination of cues. Melcher concluded that young children, as young as three years, can learn a difficult motor task when it is presented to them visually.

Melcher's results, which indicated the importance of visual cues in a child's learning process, did not agree with the beliefs of the times - that a child initially

explored his environment through touch rather than through vision. This disagreement stimulated further research into the role of touch and vision (haptic and visual perception) in the learning processes of children.

Abravanel (1968a) observed age changes in perceptual processes as he studied children (three to five and six to seven years of age) and their ability to determine spatial relationships utilizing visual and haptic modalities. Based upon the premise that by preschool age an interaction existed between visual and haptic perception and that preschoolers could demonstrate this interaction, Abravanel proposed that a process difference existed between the two types of exploration. He attempted to clarify the quality and accuracy of this difference. In his 1972 study, preschool and kindergarten children (mean age - four years, four months) were observed. Each child was seated behind a screen through which he could place his hands for object exploration. All haptic exploration was filmed. Two sets of shapes were presented to each child with the second set being perceptually more difficult. Set I contained ten groups of three wooden shapes, two of which were identical. The standard and its twin were differentiated from the third by changes in size and shape. Set II contained ten pairs of solid sculptured shapes which were identical and which contained protruding items of different shapes and sizes. Both sets were comprised of unfamiliar

but graspable shapes requiring that a child actively explore the object.

The children were randomly divided into one of three groups which were haptic-visual, visual-visual, and haptic-visual-visual. In the haptic-visual group, the children explored the shapes with both hands but without vision. After exploration of ten seconds, the children were visually presented with two shapes, one of which he selected as matching the standard he had explored. In the visual-visual group, the children visually explored the standard which was lying on the table beside him. After ten seconds, the twin and third shape were placed at the opposite end of the table and the children were asked to match the shape to the standard. In the haptic and visual-visual group, the children were asked to explore both haptically and visually the standard which was placed on the table beside them. After ten seconds, the twin and third shape were placed on the table opposite the standard and the child was asked to match the shape to the standard.

After observing the films of the haptic exploration, it was concluded that when vision was available, the hands were used only to rotate a figure and to place it in the other hand. Most exploration was done visually, with little haptic involvement. When vision was not available, however, the hands actively explored lines, angles, etc. The conclusion was that four-year-olds utilized haptic

exploration only when vision was occluded. The same observations were made in studying films from both Sets I and II.

While film observation pointed out similar utilization of visual cues by both four and five-year-olds, a significant difference was found in the accuracy between the two age groups, with the five-year-olds being more accurate.

In regards to accuracy in Set I, a significant difference was obtained between matching with haptic and matching with visual explorations, with the former being the more difficult. Accuracy in Set II displayed similar results with haptic exploration matching being significantly more difficult. There was also an improvement in visual discrimination with age as five-year-olds performed better than four-year-olds. Abravanel (1972) concluded that by four to five years of age, children preferred to explore unfamiliar and complex shapes using the visual system.

Jessen and Kaess (1973) believed that at least two hypotheses existed concerning the relationship between haptic and visual exploration in discriminating shapes. The first hypothesis maintained that active exploration through either the visual or haptic senses was important in providing corrective feedback between the two individual modalities. As a result of experience with an object in one modality, an image was formed which served to modify and adjust perception in the other sense modality. Proponents of this hypothesis included Piaget and Inhelder (1956) and

Zaphorazhets (1965). The second hypothesis contended that, conversely, intersensory communication did not occur with active exploration. A proponent of this hypothesis, Gibson (1969), believed that the senses were independent and as such independently explored and stored information. Pick (1970) supported this sensory independence hypothesis by pointing out that, while a shape can be explored visually and haptically, color can only be explored visually.

Utilizing the first hypothesis as a base, Jessen and Kaess (1973) studied 72 three and five-year-old children who were enrolled in visual and visual-haptic training programs. If there indeed was a connection between the two modalities, they hypothesized that visual-only training would improve visual-haptic matching as much as visual-haptic training. If, however, no connection existed, then training in both sensory areas would be required to improve visual-haptic matching.

The subjects, after random placement in one of three groups (vision only, vision-haptic, and control) were then screened for understanding of the concept of "sameness." In testing visual exploration, both raised and flat shapes were presented fifteen inches vertically and at eye level from the child. Shapes used for comparisons were horizontally arranged in front of the child. He touched the comparison shape which was identical to the standard. In

testing visual-haptic exploration, the child felt a concealed shape placed inside a box. He then touched the identical shape from the three stimuli, which were horizontally in front of him. In all training groups, the child watched the examiner remove indented shapes from three puzzles. In the vision-only groups, the child told the examiner where to place each shape. In the visual-haptic group, the child was permitted to place the shape into the puzzle. Eighteen training trials were given to each child.

MANOVA yielded a significant increase in performance level from three to five years of age. No significant sex differences were found. A significant difference was also found on the type of test, with performance on the vision test being more accurate than performance on the vision-haptic test. A significant difference was also found between training types, with the children from the visual-haptic training group performing significantly more accurately than the vision-only group. Thus, performance on the visual-haptic test was enhanced by training in vision and touch, but not by training in vision alone. This opposed Jessen and Kaess' (1973) hypothesis that training in one modality would increase performance in both modalities. The study supported Gibson's (1969) premise that the visual and haptic modalities were independent and therefore required separate training.

Summary

Melcher (1934) established the importance of the use of visual cues by children while learning a motor task. Since Melcher's results did not concur with the general belief that a child initially explored his environment through touch rather than through vision, research was stimulated in this area. Results of studies by Abravanel (1968a, 1972) concurred that children of preschool and kindergarten age preferred visual rather than haptic examination of new objects. Jessen and Kaess (1973) found that cross-modal matching (vision and touch) improved with age, while improvements in each modal performance occurred only through training each modality.

Visual perception and Motor proficiency

Getman (1971) defined sight as the eye's reaction to light while vision was defined as a person's total reaction to the environmental information gathered as a result of sight. The two systems - sight and vision - operated and developed together, with separation of the two a terribly difficult task. Getman (1971) believed that what optometrists called vision physical educators called motor development. He upheld that there was a reciprocal relationship between vision and movement, with vision serving as the guiding system for movement and movement functioning as the action system for vision.

Jones (1972) attempted to gather empirical support for Sherrington's (1951) theory of movement-sensory interrelationship. This theory proposed that since the motor cortex of the brain received fibers from each sensory area, a unification between the sensory and motor cortical areas must exist. Jones (1972) hypothesized that if active movement involving visual perceptual skills served to facilitate a child's judgment of length and form discrimination, then the hypothesis of intersensory connections between the sensory and motor cortex would have been supported.

In his first experiment, Jones studied 45 children (mean age - five years, four months) who were placed at random in one of three groups: 1) visual condition group; 2) active-movement condition group; and, 3) passive-movement condition group. In the visual condition group, the child inspected the initial distance between two stops (placed on a rail) which were then moved together. The stops were moved apart again until the child felt the initial distance was reached. In the active-movement condition group, the child visually inspected the distance between the stops and then placed his index finger in a thimble and moved the thimble between the stops. The stops were moved together and the child was instructed to move the stops to the initial distance. In the passive-movement condition group, the child inspected the stop distance with the experimenter moving the child's arm. As in the other

groups, the stops were moved together and the child was instructed to move the stops to the initial distance. Results from the ANOVA revealed a significant Groups Effect. The active-movement group out-performed the other groups. Jones explained these results by proposing that active-movement involvement coupled with visual perceptual skills served to increase the accuracy of visual recognition of length when a purely visual standard condition was used as a baseline. Thus it appeared from Jones' (1972) results that there could be an interconnection between the sensory and motor cortical areas.

In a second experiment conducted by Jones (1972), the children (mean age - five years, seven months) studied two-dimensional forms which were unfamiliar to them. In the visual group, each child viewed the standard form on the tray. In the active-movement group, the child inserted and moved a stylus in a ridge surrounding the standard form. In the passive-movement group, the experimenter moved the child's arm as he moved the stylus around the standard form. After observation was completed, the standard was replaced with three forms. The child was to identify by pointing to the form that was identical to the standard.

Results indicated a significant difference between groups with the active-movement group again out-performing the other groups. This evidence also supported the hypo-

thesis that active-movement facilitated visual perception (discrimination).

As research similar to that of Getman (1971) and Jones (1972) accumulated, a growing trend appeared in the literature which emphasized the importance of developmental movement in relation to perceptual-motor sophistication. Getman (1965) and Dunsing and Kephart (1965) concurred that cognitive development was enhanced by a mature development of the sensory-motor and perceptual-motor processes. Without this sound base, complex learning would be threatened. From this thinking, it was believed that learning disabilities could arise from inadequate perceptual-motor development.

Auxter (1971) studied 17 normal (mean age - seventy-one months) and 18 learning disabled (mean age - seventy months) children in the areas of strength, flexibility, general motor development, and perceptual motor ability in an effort to determine differences between groups. The test battery included the following tests: 1) hand dynamometer; 2) toe touch; 3) standing broad jump; 4) Fleishman's test of dynamic flexibility; and, 5) ball-catching subtest from the Iowa Brace Scale (1943). No significant differences were found between groups on the tests of hand strength and toe touch. However, significant group differences were found for dynamic flexibility, ball catch, and broad jump, with the normal children out-performing

the learning disabled children. Auxter (1971) attributed the non-difference between groups in the hand strength and toe touch as possibly due to a lack of higher-order thinking demanded to perform the tasks. The three tasks revealing significant differences (dynamic flexibility, ball catch, and broad jump) however, required a higher and more sophisticated sensori-motor interaction and therefore acted as better discriminators between groups. Auxter (1971) concluded by hypothesizing that the learning disabled group was unable to adequately and efficiently process sensori-motor information.

Similar conclusions were drawn by Williams (1972), who grouped and labeled seven-year-old children as slowly developing (SD) or normally developing (ND). This grouping was based on the classroom teachers' classification of the child after having worked with the child in an academic setting for several months. Williams (1972) hypothesized that because ND children were better able to process intersensory information than SD children, then ND children should perform significantly better on motor tasks. The children were given a battery of tests which included three balance tasks (static balance, eyes closed; balance beam walk; balance beam kneel), three agility tasks (shuttle run; 50 foot hop; obstacle course), a ball-handling task (ball bounce), and a power task (standing broad jump). Near equal group performance was observed on those tasks

requiring a lower level of sensory information processing, including static balance and the balance beam walk. As the task required more sophisticated sensory integration, a significant group difference occurred with the ND group performing with significantly fewer falls and requiring significantly less time (on the balance beam walk and 50 foot hop) than the SD group. Williams (1972) suggested that a developmental difference actually existed between ND and SD children and attributed this difference to the child's level of intersensory development.

Some researchers (Fitts and Posner, 1967 and Connolly, 1970) suggested that instead of intersensory integration being the base for successful perceptual-motor task performance, the serial order (sequencing) of a task more effectively discriminated the skilled from the less-skilled performer. Zaichowsky (1974) questionned the cause of a child's difficulty in sequencing and hypothesized that it was due to an immature short-term memory. Sequencing was defined as the ability to organize task information in a serial order. He studied 120 children (ages five, seven, and nine years) and their ability to utilize short-term memory in sequencing tasks. Perceptual-motor responses were measured by a specially designed Serial Perceptual-Motor Discriminator (SPMD). All children were pretested for the understanding of "same order," followed by demonstration of the SPMD. They were then randomly divided

into two groups. Group I received the stimulus (a red light) in an organized (O) pattern while Group II received the stimulus in a random (R) pattern. A red light was placed in front of the child's right arm (RA), left arm (LA), right leg (RL), and left leg (LL). A stimulus pattern consisted of eight serial positions for responding to the red light with the O group responding to LA, RA, RL, LL, LA, RA, RL, LL pattern and the R group responding to LA, RL, LL, RL, RA, LL, LA, RA pattern. As the red light flashed, the child pressed a switch with the appropriate limb. Upon completion of this stimulus-response pattern, a GO signal cued the child to replicate the pattern order from memory. Upon completion of this task, the red lights were again utilized, with the stimulus-response and memory patterns occurring until the child could perform two successive trials from memory. No more than twenty-five trials were given. Results yielded a significant age effect, with the greatest gains in performance occurring between five and seven years. This indicated that sequencing ability matured with age. A significant difference was also obtained between R and O patterns, with the O pattern yielding fewer errors than the R pattern. This indicated that organized sequences were remembered better than unorganized sequences. Children in all age groups were able to remember early responses more accurately than responses occurring in the middle or end of the pattern. The older

children displayed fewer errors. Zaichowsky attributed the better recall ability of older children to their more mature verbal labeling skills which enhanced memory.

Ross (1961) administered visual perceptual tests and motor tests to 90 second, fourth, and sixth grade children. The visual perceptual tests included the following tasks: 1) size constancy; 2) figure alternation; 3) lateral phoria; 4) stereopsis; 5) binocular acuity; and, 6) monocular acuity. The visual tests were measured with the following instruments: 1) Keystone telebinocular; 2) Keystone Visual Survey Unit; 3) Renshaw Visual Diagnostic and Training Split Stereogram Series. Ross (1961) devised her own motor tests, which included the following tasks: 1) ball bounce task, in which the child bounced a ball and caught it below the waist; 2) wall bounce catch task, in which the child caught a rebounded ball from above the waist (rebounded off the wall); 3) ring toss test in which the child passed his hand and arm through a ring tossed to him by the experimenter; and, 4) target throw task, in which the child tossed a bean bag toward a target board. From this study, Ross (1961) attempted to determine the following:

1. The relationship between visual perception and eye-hand coordination
2. Age and sex differences in visual, motor, and eye-hand coordination skills
3. The relationship between visual skills and motor skills when a ball is caught above and below the waist

4. The relationship between visual skills and a specifically hit target area
5. Which visual skills accurately predicted eye-hand coordination
6. A serial order of visual skills for each motor task

Because of the complex and elaborate statistical analysis and results, only those results pertaining directly to this study will be discussed. A multiple regression equation was used to determine the relationship between eye-hand coordination and visual functions. The ball bounce task yielded a coefficient of multiple determination of .739, indicating that almost 55% of the variance in this task was due to vision variables. Of all the motor tasks, the ball bounce catch was the most significantly influenced by the vision variables.

Summary

The general concensus of researchers studying visual perception and motor proficiency was that children who displayed poor sensory processes also displayed poor motor processes. Getman (1971) observed that children exhibiting poor visual functions also exhibited poor motor abilities. Williams (1972) and Auxter (1971) found that normally-developing children were better able to process higher-order sensori-motor information. Jones (1972) found that active involvement facilitated visual perception while Zaichowsky (1974) found that older children exhibited better recall

ability, perhaps due to more mature labeling strategies. Ross (1961) found that performance on motor tasks generally improved with age and that some motor tasks (especially her ball bounce task) were greatly influenced by visual functions.

CHAPTER III

METHODOLOGY

Statement of the Problem

The purpose of this study was to determine if five-year-old children, displaying high or low ability to process visual information, exhibited the same high-low ability in proficiency of motor tasks which were dependent upon visual information for successful completion.

Subjects

40 five-year-old children (26 girls and 14 boys) were selected at random from four nursery schools. The schools were chosen at random from phones books and were located within the Kent-Stow-Akron area. The subjects were from mixed socio-economic backgrounds. The ages of the children ranged from 51 - 74 months. Only those children meeting public school requirements for entrance to kindergarten were studied. Children with subnormal acuity or physical handicaps did not participate.

Tests and Apparatus

Two classifications of tests were used in this study:

Visual Tests and Motor Performance Tests. The visual tests included the Titmus Biopter, Purdue Modified Ocular Pursuits, visual subtests of the Illinois Test of Psycholinguistic Abilities (ITPA), and Ayres Figure Ground Test. The Motor Performance Tests included Bounce Catching, Aerial Catching, Stationary Striking, Moving Striking, and Visual Motor Sequential Memory.

The Visual Tests

1. Titmus Biopter: The Biopter is a small table device which contains an illuminated screen upon which cards, designed to measure different visual components, are placed. As the child looks through two lenses, he is asked to identify specific items which relate to the following visual functions:

a. visual acuity: the ability to see, both monocularly and binocularly, at near and far distances.

b. vertical phoria: the ability of the ocular muscles to work together in a vertical plane, at far distances.

c. lateral phoria: the ability of the ocular muscles to work together in horizontal and lateral planes, at both near and far distances.

d. central fusion: the ability of the eyes to work together by combining (fusing) the images received by both eyes into one image, at both

near and far distances.

e. stereopsis: the ability of the eyes to detect depth.

The scores from each test were recorded on a standardized score sheet (see appendix) which was divided into light and shaded areas. The shaded area indicated insufficient visual functioning. Any child failing the acuity subtest did not participate in the study.

2. Purdue Modified Ocular Pursuit Test: The Ocular Pursuit test item was selected from the Purdue Perceptual Motor Survey (Roach and Kephart, 1966) to measure visual tracking. This test required the child, while keeping his head stationary, to track the movement of a penlight, which was moved in the following ways: 1) up and down; 2) right and left; 3) diagonally right and left; 4) circularly; and, 5) toward and away from the nose. The test was given both binocularly and monocularly. In order to score a pass, a child performed with smooth, even-following movements or with minimal jerkiness or hesitation. In order to score a failure, the child performed with uneven, jerky movements, inability to follow the target without moving the head, or lack of parallelism between the two eyes.

3. Ayres Figure Ground Test: This test determined the ability to identify an object from its surroundings. The test booklet contained sixteen sets of pictures which were used for the discrimination and identification of specific

objects. The child was asked to look at the standard object presented on one page. He was then instructed to point to an identical representation of the standard object placed in context with four to six other items on the adjacent page. The motor response of drawing, so commonly found in figure-ground tasks, was eliminated. The score was the total number of correct responses. The estimate of reliability for this test has been reported as .88.

4. ITPA Visual Subtests: The visual subtests selected from the ITPA test battery measured the following visual components:

a. visual sequential memory: This test assessed the ability of the child to reproduce, from memory, non-meaningful symbols. The child was asked to observe a sequence of symbols for five seconds. After removal of the symbols, the child was asked to replicate what he had seen by placing chips containing corresponding symbols on a tray. Two trials were given for each sequence, with the points given for each correct sequence on the first trial, and one point given for each correct sequence on the second trial. The score was the total number of points accumulated. The sequence increased in length from two to eight symbols. Reliability has been reported as .74 for children four years, seven months (4-7) to 5-1, and .69 for children 5-7 to

6-1 (Paraskevopoulos and Kirk, 1969).

b. visual association: This assessed the ability of the child to organize and relate meaningful visual symbols. A stimulus picture, surrounded by four pictorial choices, was presented to the child. The child must point to the appropriate picture relating to the stimulus. Twenty single items were presented, followed by twenty-two visual analogies. The score was the number of correct responses before two consecutive errors were made. Reliability was reported as .82 for children 4-7 to 5-1, and .75 for children 5-7 to 6-1 (Paraskevopoulos and Kirk, 1969).

c. visual closure: This assessed the ability of the child to comprehend and identify a whole object when visually presented with an incomplete picture. Four scenes containing fourteen to fifteen partially concealed objects were presented to the child. The child had thirty seconds in which to identify the objects in each scene. The score was the total number of objects found in four scenes.

d. visual reception: This assessed the ability of the child to understand visual symbols. Forty symbols were pictured. Each symbol, identified on a stimulus page, was followed by a response

page containing four pictures. The child looked at the stimulus page for three seconds, then the response page was presented. The child pointed to the picture which was structurally similar to the stimulus. Total score was the number of correct responses before three consecutive errors were made. Reliability was reported as .86 for children 4-7 to 5-1, and also for children 5-7 to 6-1 (Paraskevopoulos and Kirk, 1969).

The Motor Performance Tests

The Motor Performance Tests included tasks which utilized the previously discussed visual components for completion. In the Bounce Catching and Aerial Catching tests, the term successful catch was used and defined as any ball caught and held for two seconds.

1. Bounce Catching Test (BC)

Task I; BCS; This task required the child to bounce and catch a nine-inch playground ball to himself. The score was the total number of successful catches in ten trials. Reliability was reported as .74 (Williams, 1974).

Task II; BC59; This task required the child to catch a nine-inch ball tossed by the examiner from a distance of five feet after

it has bounced one time. The score was the total number of successful catches in ten trials. Reliability was reported as .99 (Sessions, 1975).

Task III: BC109; This task required the child to catch a nine-inch ball tossed by the examiner from a distance of ten feet. The score was the total number of successful catches in ten trials. Reliability was reported as .87 (Sessions, 1975).

Task IV: BC57; This task required the child to catch a seven-inch ball tossed by the examiner from a distance of five feet. The score was the total number of successful catches in ten trials. Reliability, calculated by test-retest (N=12), was .81.

Task V: BC107; This task required the child to catch a seven-inch ball tossed by the examiner from a distance of ten feet. The score was the total number of successful catches in ten trials. Reliability calculated by test-retest (N=10) was .80.

2. Aerial Catching Test (AC)

The Aerial Catching tasks were more difficult, for the child had to catch a tossed ball before a bounce

occurred. The ball was traveling at a faster rate of speed, therefore requiring more sophisticated ball-tracking ability and eye-hand coordination. In all aerial tasks, an underhand motion was executed for the toss.

Task I: AC59; This task required the child to catch a nine-inch ball tossed by the examiner from a distance of five feet. The score was the total number of successful catches in ten trials. Reliability was reported as .99 (Sessions, 1975).

Task II: AC109; This task required the child to catch a nine-inch ball tossed by the examiner from a distance of ten feet. The score was the total number of successful catches in ten trials. Reliability was reported as .87 (Sessions, 1975).

Task III: AC57; This task required the child to catch a seven-inch ball tossed by the examiner from a distance of five feet. The score was the total number of successful catches in ten trials. Reliability, calculated by test-retest (N=10) was .69.

Task IV: AC107; This task required the child to catch a seven-inch ball tossed by the examiner from a distance of ten feet. The score was the total number of successful

catches in ten trials. Reliability, calculated by test-retest (N=10) was .82.

3. Stationary Striking Test (SS)

The striking tasks employed further perceptual sophistication as the child was required to strike an object, both stationary and moving, with a bat. Thus, for a moving ball, the child not only must track the ball, but also must strike the ball with an object outside the body. For all striking tasks, a hit was constituted as any contact of the ball with the bat, regardless of distance travelled by the ball. A plastic bat 28 inches long with a circumference of 13 1/2 inches, a five-inch sponge ball, and a seven-inch playground ball were used.

For these tasks, an adjustable T-ball stand was used. The top of the stand was adjusted to the umbilical level of each child.

Task I: SS7; This task required the child to strike the seven-inch ball from the T-ball stand. The score was the total number of successful hits in ten trials. Reliability, calculated by test-retest (N=12), is

Task II: SS5; This task required the child to strike the five-inch ball from the T-ball stand. The score was the total number of successful hits in ten trials.

Reliability, calculated by test-retest, (N=12) is .82.

4. Moving Striking Test (MS)

In these tasks, the examiner, utilizing an underhand toss with mild force, pitched the ball to the child, who has assumed a batter's stance.

Task I: MS107; This task required the child to strike the seven-inch ball, pitched by the examiner from a distance of ten feet. The score was the total number of successful hits in ten trials. Reliability, calculated by test-retest (N=12) is .83.

Task II: MS157; This task required the child to strike the seven-inch ball pitched by the examiner from a distance of fifteen feet. The score was the total number of successful hits in ten trials. Reliability, calculated by test-retest (N=10) is .81.

Task III: MS105; This task required the child to strike the five-inch ball pitched by the examiner from a distance of ten feet. The score was the total number of successful hits in ten trials. Reliability, calculated by test-retest (N=12), is .89.

Task IV: MS155; This task required the child to strike the five-inch ball pitched by the

examiner from a distance of fifteen feet. The score was the total number of successful hits in ten trials. Reliability, calculated by test-retest (N=10), is .84.

5. Visual Motor Sequential Memory Test (VMSM)

In this test, the child was required to watch the examiner perform a motor task and then to repeat what he had seen. There were ten test items, with the first item involving one task and progressing to the tenth item involving nine tasks. Each item was scored by the total number of movements included in the sequence. The total possible score was forty-two, representing the number of times the child observed a movement and repeated it correctly. Reliability, calculated by test-retest (N=12) is .94. (See appendix for test items.)

PROCEDURE

The administration of all test items took place in rooms where little interruption occurred. Of the four nursery schools, three allowed the examiner to use a classroom, while a dining room was used in the fourth school. Because two hours were required to administer the complete test battery to each child, the tests were administered in four sessions. Children with shorter attention spans, determined at the discretion of the examiner, were given an extra break or were tested during

another session. All children were tested on a one-to-one basis.

After setting up the apparatus, the examiner would enter the classroom to select a child. Returning to the testing area, the child would be seated at a table next to the examiner. A pretest was given for knowledge of a) the alphabet A through E; b) the symbols of a star, circle, triangle, square, and cross; and, c) the numbers one through eight. All items were required for the Biopter test and were presented on index cards. The pretest required the child to identify the item as the examiner pointed to it. Upon completion of the pretest, the Titmus Biopter test was given. Any child failing the acuity subtest did not participate in the study. From this point, the subjects progressed through the following three sessions, which were randomly ordered for each child.

Session I: This session included the Purdue Modified Ocular Pursuit Test, the visual subtests of the ITPA, and the Ayres Figure Ground Test. The child was seated facing the examiner and asked to select a Disney character (Mickey Mouse, Pluto, Dumbo, Pinocchio) for the next game. After placing the character on the penlight, the examiner administered the Purdue Modified

Ocular Pursuit Test.

For the Ayres Figure Ground Test, the child moved to the other side of the desk, opposite the examiner. A break was given at the completion of this test, with the child getting a drink, using the bathroom, or stretching and running. Upon return, the child was given the visual subtests of the ITPA in the following order: visual reception, visual sequential memory, visual association, and visual closure. Standardized procedures were followed. If a child displayed boredom or restlessness, an additional break was given. After completion of the test, the child returned to the classroom.

Session II: This session included the catching sequences. All bounce-catching tasks were performed on indoor-outdoor carpeting. After escorting the child to the testing area, the examiner placed him behind the appropriate line, explained the "game," and after demonstrating, proceeded with the testing. One practice was given, with further

explanation if necessary. At this time, the child returned to the classroom.

Session III: This session included the striking sequences. To facilitate administration of these tasks, a "helper" was used to catch missed balls. This was the only situation in which the child did not perform alone. Upon entering the testing area, the examiner adjusted the T-ball stand to the umbilical level of the child. Instructions were then given for batting stance. The instructions were given regardless of previous batting experience. However, no attempts were made to correct batting stance if the child had his own stance from previous experience. The stationary striking tasks were performed first. If the stand rather than the ball was hit, the trial was unsuccessful. If the ball and stand were hit simultaneously, the trial was successful.

Upon completion of the stationary striking tasks, the examiner moved the child behind a line from where the moving

striking tasks were performed. If the examiner executed a pitch which did not reach the child, that pitch was excluded. A break was given after the tasks with the seven-inch ball were completed. Upon returning, the same procedure was used with the five-inch ball.

Session IV: This session included the Visual-Motor Sequential Memory Test. The examiner performed the first task. After watching, the child performed the task as he remembered it. Each task was presented until all tasks were performed by the child. At this time, the child returned to the classroom.

Statistical Treatment of Data

Data analysis consisted of a principal component factor analysis which was conducted to identify common factors and reduce the dependent variable list. Using the identified factors from the factor analysis and their components, the children were assigned to a High or Low group for each factor. A series of MANOVAs and discriminant function analyses were conducted to determine significant differences between high-low groups.

CHAPTER IV

RESULTS

Statement of the Problem

The purpose of this study was to determine if five-year-old children, displaying high or low ability to process visual information, exhibited the same high-low ability in proficiency of motor tasks which were dependent upon visual information for successful completion.

Overview of the Chapter

Based upon statistical treatment of data, this chapter was divided into the following sections: 1) Results of factor analysis; 2) Results of multivariate analysis of variance and discriminant function analyses for high-low group differences; and, 3) Summary. The factor analysis section included identification of principal components and the loading of six factors. The MANOVA section included a description of group assignment and selection of dependent variables. The MANOVA section also revealed mean differences of the high-low groups, F-ratios, p-values, and discriminant function coefficients for each identified factor. A discussion section followed each factor and a summary concluded the chapter.

Results of the Factor Analysis

To identify common factors and reduce the dependent variable list, a principal component factor analysis with iterations and subjected to Kaiser varimax rotation was conducted. A factor loading of .72 was used to identify a significant loading. This was determined by using Bartlett's Sphericity Test to calculate whether the correlation matrix was essentially the identity matrix. An estimate of the critical value of factor loadings was produced which provided the assurance that when the correlation matrix was factor analyzed, loadings whose absolute values were greater than the critical value were significantly greater than zero. The factors that emerged from this analysis are shown in Table I.

Six factors were identified which included one visual factor and five motor factors. Factor I. Vision (V) included loadings from figure-ground, visual association, and visual reception. Factor II. Stationary Striking (SS) included loadings from all SS tasks using both seven-inch and nine-inch balls. The SS total score yielded the highest loading. Factor III. Moving Striking (MS) included loadings from all MS tasks which were those using the five-inch ball from fifteen feet and the seven-inch ball from ten and fifteen feet. The MS total score yielded the highest loading. Factor IV. Bounce Catching Five (BC5) included all BC tasks performed at the five-foot distance. The BC5 total score yielded the

Table 1

Principal Component Factor Analysis

FACTOR I: VISION		FACTOR II: STATIONARY STRIKING	
Figure Ground	-.741	SST	.942
Visual Association	-.704	SS5	.830
Visual Reception	-.691	SS7	.738
Visual Sequential Memory	-.490		
Eigen Value	7.658	Eigen Value	3.451
% Variance	8.6102	% Variance	10.3521

FACTOR III: MOVING STRIKING		FACTOR IV: BOUNCE CATCHING (5 Ft.)	
MST	.923		
MS155	.915	BC5T	-.917
MS157	.847	BC57	-.843
MS107	.708	BC59	-.829
Eigen Value	2.526	Eigen Value	2.146
% Variance	19.681	% Variance	13.288

FACTOR V: BOUNCE CATCHING (10 Ft.)		FACTOR VI: AERIAL CATCHING	
		ACT	.866
BCT	.820	AC59	.720
BC109	.755	AC107	.717
BC107	.633	AC109	.706
Eigen Value	1.890	Eigen Value	1.578
% Variance	9.1256	% Variance	12.9955

Accum % of Total: 74.0329

highest loading. Factor V. Bounce Catching Ten (BC10) included all BC tasks performed at the ten-foot distance. The highest loading on this factor was the BC10 total score. Factor VI. Aerial Catching (AC) included catching from the ten-foot distance using the nine-inch and seven-inch balls and catching from a five-foot distance using the nine-inch ball. The highest loading on this factor was the AC total score.

Discussion: Results of the factor analysis were logical and as expected. The visual measures (figure ground, visual association, and visual reception) loaded together, providing evidence that they were tapping similar processes. The tasks from each similar motor area also loaded together regardless of the size of ball or distance. All MS tasks appeared to be tapping similar functions; all SS tasks appeared to be tapping similar functions; and, all AC tasks appeared to be tapping similar functions. The BC tasks, however, were different as the ten-foot tasks and the five-foot tasks loaded separately. The five-foot distance required an almost automatic response by the child to catch the ball. Apparently, the distance was not great enough to utilize higher order tracking or figure ground abilities. Rather, the ball simply bounced into the child's arms. In the ten-foot task, not only was the child required to focus on the ball utilizing tracking and figure ground abilities, but was also required to move his body in relation to the ball for

successful catching. Thus, more perceptual sophistication was required.

In all factors, the total score was the highest loading. Since each total score was comprised of the individual task scores, this was logical.

Results of MANOVA

In an effort to determine if children who performed well on tests of visual proficiency also performed well on motor tasks dependent upon vision for successful completion, a series of MANOVAs were run for Groups (high-low).

Using the identified factors from the factor analysis and their components, the children were assigned to a High or Low Group for each of the six factors. For Factor I Vision, the children's scores on the four measures which loaded on this factor were arranged from high to low. By observing or "eye-balling" the scores, group assignment was determined by placing those children receiving high scores for each test in the high group and those children receiving low scores on each test in the low group. Ten children were placed in each group. The motor high-low group assignments were determined by selecting the ten highest and ten lowest total scores. In some instances, in both the vision and motor group assignments, there were tied scores which increased the group size beyond ten.

Once the high-low group assignment had been completed,

a MANOVA was conducted for the Vision Factor, using the tasks which loaded on the Motor Factors (ACT, SST, MST, BC5T, BC10T) as dependent variables. This analysis was followed by MANOVAs for each Motor Factor: High-Low Groups using as dependent variables the items which received the highest loading on the Vision Factor (figure ground, visual association, visual reception, visual sequential memory).

Results from Multivariate Analysis of Variance and Discriminant Function Analysis

Vision Tasks

Factor I: Vision. Mean trends, shown in Table II and Graph I, reflected a tendency for the high group to perform better than the low group on all motor tasks except BC5 and BC10. The greatest difference between group means, although not significant, occurred on MS. MANOVA results yielded no significant difference between groups ($F = .657$, $p < .66$).

Discussion: Although mean differences were observed, the group differences were still not significant. Since the vision variables were measured by a standardized test, requiring no movement for successful completion, apparently there was no carry-over of task specificity from visual to motor tasks. The child had to sit and look, not move and look. Therefore, visual perception, as measured by the ITPA, couldnot be generalized to movement.

Table 2

MANOVA and Discriminant Function Analysis for FACTOR I, VISION: High vs. Low Groups

FACTOR I: VISION

MEANS	ACT	SST	MST	BC5T	BC10T
High	30.09	17.82	27.27	17.27	16.82
Low	29.60	16.20	24.00	18.00	17.20
STANDARD DEVIATIONS	ACT	SST	MST	BC5T	BC10T
High	6.58	2.18	8.04	2.05	2.86
Low	6.36	2.97	6.73	1.76	2.30

GROUPS (High-Low)	df	F	P
High N = 11 Low N = 10	5,15	0.657	<.66

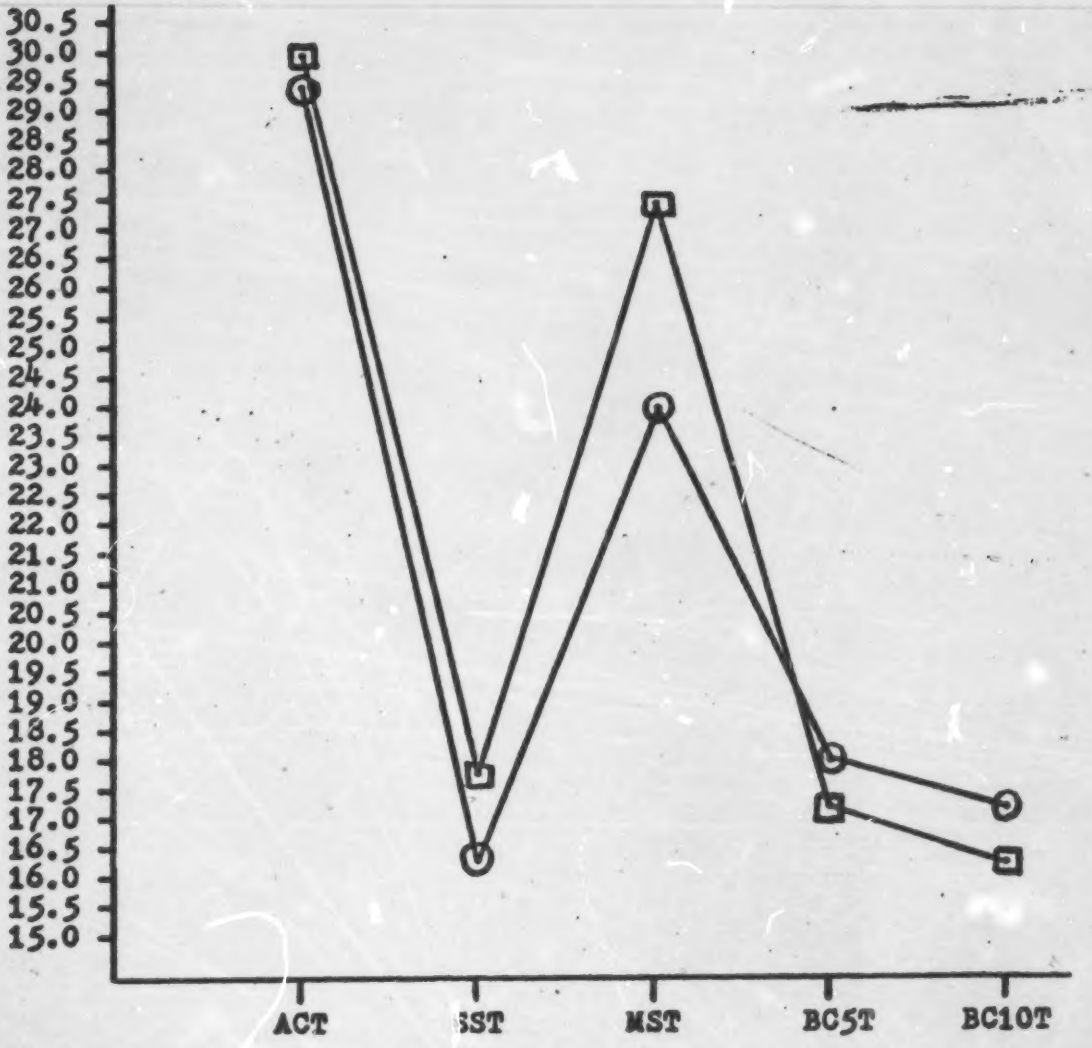
	MEAN SQUARE	UNIVARIATE F	P	STEP DOWN F	P	STAND. DISC. FUNCTION COEF.
ACT	1.26	0.03	0.86	0.03	0.86	0.27
SST	13.72	2.05	0.17	2.09	0.17	0.85
MST	56.10	1.01	0.33	0.60	0.45	0.50
BC5T	2.77	0.75	0.40	0.52	0.48	0.11
BC10T	0.76	0.11	0.74	0.30	0.59	0.53

CORRELATION MATRIX

	ACT	SST	MST	BC5T	BC10T
ACT	1.000				
SST	-0.182	1.000			
MST	0.455	0.023	1.000		
BC5T	0.168	0.006	-0.05	1.000	
BC10T	0.455	0.200	0.30	0.636	1.000

Graph I

MEANS: FACTOR I, VISION



Low Group - O
High Group - □

Motor Tasks

Factor II: Stationary Striking. Mean trends, shown in Table III and Graph II, reflected a tendency for the high group to consistently perform better than the low group with the greatest difference occurring in visual reception. MANOVA results yielded no significant difference between groups ($F = 0.69$, p .61).

Factor III: Moving Striking. Mean trends, shown in Table IV and Graph III, reflected a tendency for the high group to perform better on figure ground, visual reception, and visual association while the low group performed better on visual sequential memory. The greatest group difference occurred in visual sequential memory. MANOVA yielded no significant difference between groups ($F = 1.07$, $p < .39$).

Discussion: Although MANOVA yielded no significant group differences, several interesting observations were made from group mean trends. It was rather surprising that the high SS group consistently out-performed the low SS group as these tasks were not considered to be perceptually demanding. The child contacted a non-moving ball which involved the perceptual components of figure ground perception and eye-hand coordination. According to Aaron (1972), one epigenetic factor identified as facilitating learning was inhibition, or the ability to attend to only relevant information. Perhaps the high SS group was better able to attend to the task at hand, blocking out any interfering

Table 3

MANOVA and Discriminant Function Analysis for
FACTOR II, STATIONARY STRIKING: High vs. Low Groups

FACTOR II: STATIONARY STRIKING

MEANS	FG	VR	VSM	VA
High	10.93	21.53	19.13	17.00
Low	9.57	18.93	17.29	14.79
STANDARD DEVIATIONS	FG	VR	VSM	VA
High	4.32	5.76	4.45	3.44
Low	3.08	4.45	5.00	6.86
GROUPS (High-Low)		df	F	P
High N = 16 Low N = 14		4, 24	0.69	< .61

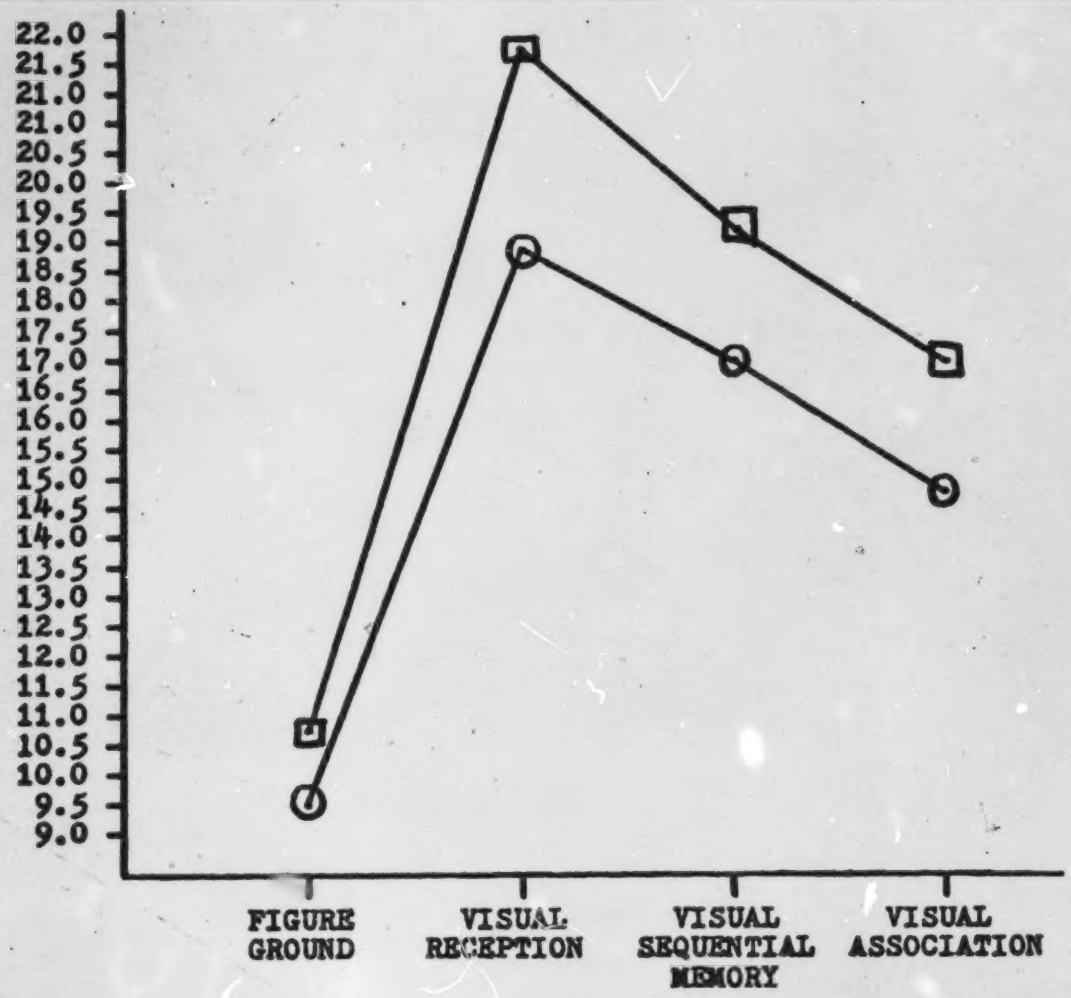
	MEAN SQUARE	UNIVARIATE F	P	STEP DOWN F	P	STAND. DISC. FUNCTION COEF.
FG	13.43	0.94	0.34	0.94	0.34	-0.20
VR	49.13	1.84	0.19	1.04	0.32	-0.49
VSM	24.72	1.11	0.30	0.71	0.41	-0.53
VA	35.50	1.23	0.28	0.17	0.69	-0.31

CORRELATION MATRIX

	FG	VR	VSM	VA
FG	1.000			
VR	0.400	1.000		
VSM	0.012	0.126	1.000	
VA	0.490	0.434	0.019	1.000

Graph 2

MEANS: FACTOR II, STATIONARY STRIKING



Low Group - O
High Group - □

Table 4

MANOVA and Discriminant Function Analysis
for FACTOR III, MOVING STRIKING: High vs. Low Groups

FACTOR III: MOVING STRIKING

MEANS	FG	VR	VSM	VA
High	10.53	21.27	16.87	17.93
Low	9.42	20.17	19.42	15.83
STANDARD DEVIATION	FG	VR	VSM	VA
High	3.48	5.66	5.18	5.20
Low	3.29	4.04	4.42	5.67

GROUPS (High-Low)	df	F	P
High N = 14 Low N = 14	4, 22	1.07	< .39

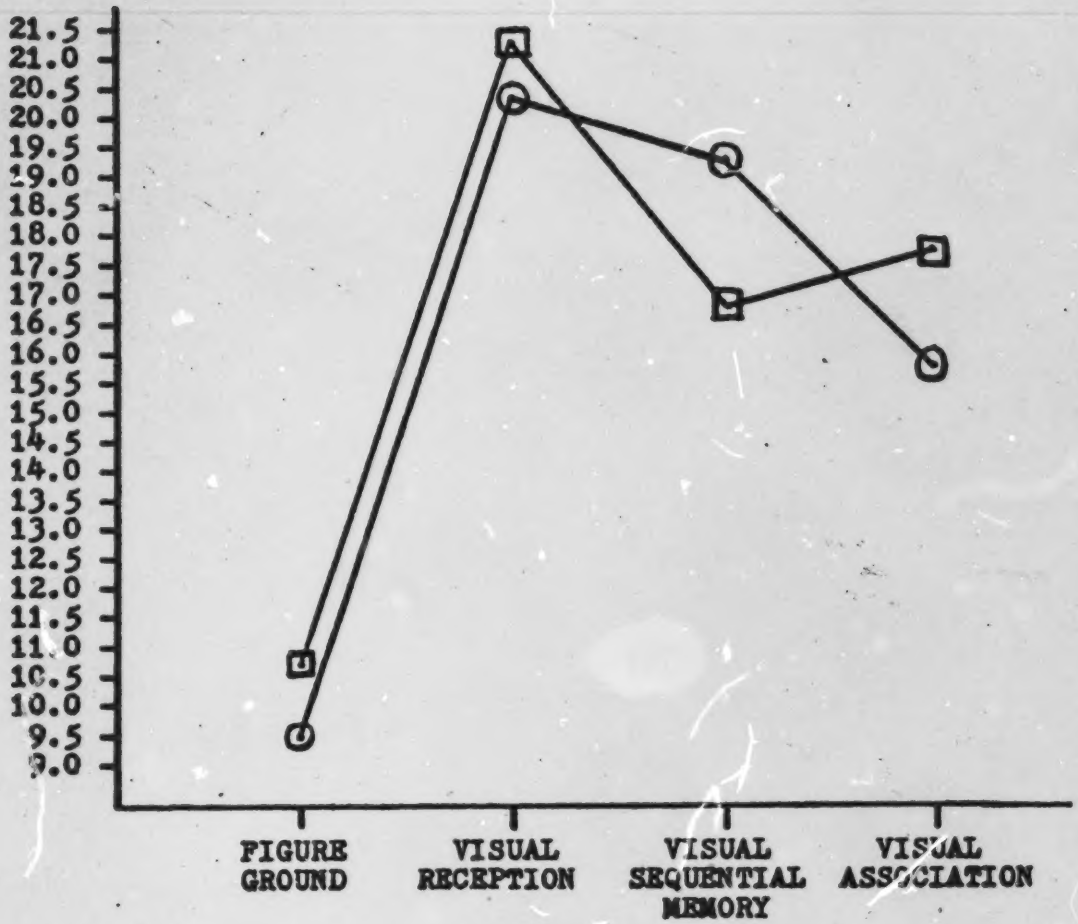
	MEAN SQUARE	UNIVARIATE F	P	STEP DOWN F	P	STAND. DISC. FUNCTION COEF.
FG	8.31	0.72	0.40	0.72	0.40	0.08
VR	8.07	0.32	0.58	0.0002	0.99	0.29
VSM	43.35	1.83	0.19	2.14	0.16	-0.96
VA	29.40	1.00	0.33	1.39	0.25	0.68

CORRELATION MATRIX

	FG	VR	VSM	VA
FG	1.000			
VR	0.655	1.000		
VSM	0.123	0.306	1.000	
VA	0.340	0.306	0.360	1.000

Graph 3

MEANS: FACTOR III, MOVING STRIKING



Low Group - ○
High Group - □

stimuli. The external stimulus - the ball on the stand - created neural impulses. The child, as a result of the neural impulses, interpreted or perceived the incoming information, utilizing only RELEVANT information and therefore successfully completing the task.

Many researchers (Fitts and Posner, 1967; Connolly, 1970) believed that a skilled performer understood the serial order (sequencing) of a task much better than a less-skilled performer. When a child organized his information, encoding as well as performance was enhanced. The conclusion was drawn that, in the SS task, the high group was better able to organize the relevant incoming information.

There was a certain sequence to the stationary striking tasks, including: 1) picking up the bat; 2) holding the bat properly; 3) sighting the ball; 4) placing the body in proper relationship to the ball; 5) selecting the proper motor program; and, 6) initiating the motor program. The inferior performance of the low group could indicate inadequate sequencing and short-term memory, as studied by Haith, et. al. (1970) and Zaichowsky (1974). Researchers concluded that, although five-year-olds indeed had sequencing ability (Piaget and Inhelder, 1956), the ability was immature. Zaichowsky (1974) revealed that the greatest gains in sequencing ability occurred between five and seven years of age. Had the children in this study been older, the group trends may have been different.

The greatest group difference on SS tasks occurred with visual reception. This was understandable as visual reception required not only input but also a mediating or organizing process before output occurred. Although the tasks were not the same (vision versus movement), both required that mediating or organizing step. Therefore, as the high group was thought to organize perceived material (input) better than the low group, their performance (output) was also better.

The MS tasks employed similar perceptual components as the SS tasks, but required a higher level of sophistication as the ball was moving rather than stationary. Therefore, not only were figure ground, eye-hand coordination, sequencing ability, and spatial relationship involved, but also directionality (where should the body move to contact the ball), body awareness, and the ability to monitor that moving ball. The child had to again organize only relevant information and initiate the proper motor program. However, that program could not be initiated until the child knew where the ball was coming - how fast and how high - and when to swing to contact the ball. The child had to anticipate when to begin his motor act in order to contact the ball. This indeed required a higher level of perceptual sophistication.

With this in mind, it was not surprising that the high MS group performed better on three of the four vision tasks.

It was surprising, however, and indeed disturbing, that the low MS group performed better on the visual sequential memory task, with this group difference being the greatest of all visual test. When studying the visual sequential memory test and the MS test, specific similarities were hard to determine. Again, the visual test required SITTING and SEEING while the MS task required MOVING and SEEING. Visual sequential memory required a great deal of short-term memory of non-meaningful symbols while MS required more sequencing and organizing of meaningful visual information. Therefore, those who had better short-term memory as measured by this visual test were not necessarily proficient at the MS task. That is, the motor program was new. Experience and practice were required before proficiency was obtained. When observing individual scores, two factors seemed to influence proficiency - age and experience. The older children tended to perform better while the younger children displaying better scores were those having previous baseball/softball experience. Although these children performed better on the MS task, they were not necessarily proficient on visual sequential memory. Motor programs were established for MS but "visual programs" were not established for sequencing of non-meaningful symbols.

A tendency was noted when observing individual scores that the number of successful hits generally decreased between SS and MS tasks. This indicated that the MS task

was indeed more difficult, placing more demands on the inter-sensory communication system.

Factor IV: BC5. Mean trends, shown in Table V and and Graph IV, reflected a tendency for the low group to perform better on visual association, visual sequential memory, and figure ground with near-equal performance on visual reception. The greatest mean differences occurred on visual association. MANOVA results yielded no significant group difference ($F = .91$, $p < .49$).

Factor V: BC10. Mean trends, shown in Table VI and Graph V, reflected a tendency for the high group to perform better on visual reception and visual association while the low group performed better on visual sequential memory. Near-equal performance was obtained on figure ground. The greatest mean differences occurred in visual sequential memory. MANOVA results yielded a significant difference between high-low groups ($F = 4.17$, $p < .01$). The Standard Discriminant Function Analysis indicated that visual reception, with a coefficient of 1.20, was the best predictor of group membership.

Discussion: No group differences were found on the BC5 task because the five-foot distance was not great enough to require sophisticated visual perceptual components. The BC5 catch was almost automatic; the ball, after bouncing half-way between the Experimenter and the child, simply fell into the child's outstretched arms, requiring little organi-

Table 5

MANOVA and Discriminant Function Analysis for
FACTOR IV, BOUNCE CATCHING FIVE TOTAL: High vs. Low Groups

FACTOR IV: BOUNCE CATCHING FIVE TOTAL

MEANS	FG	VR	VSM	VA
High	8.57	20.29	17.86	15.00
Low	10.10	20.00	20.30	18.30

STANDARD DEVIATIONS	FG	VR	VSM	VA
High	2.70	2.69	4.60	6.00
Low	3.28	3.92	3.86	6.57

GROUPS (High-Low)	df	F	P
High N = 7 Low N = 10	4, 12	0.91	<.49

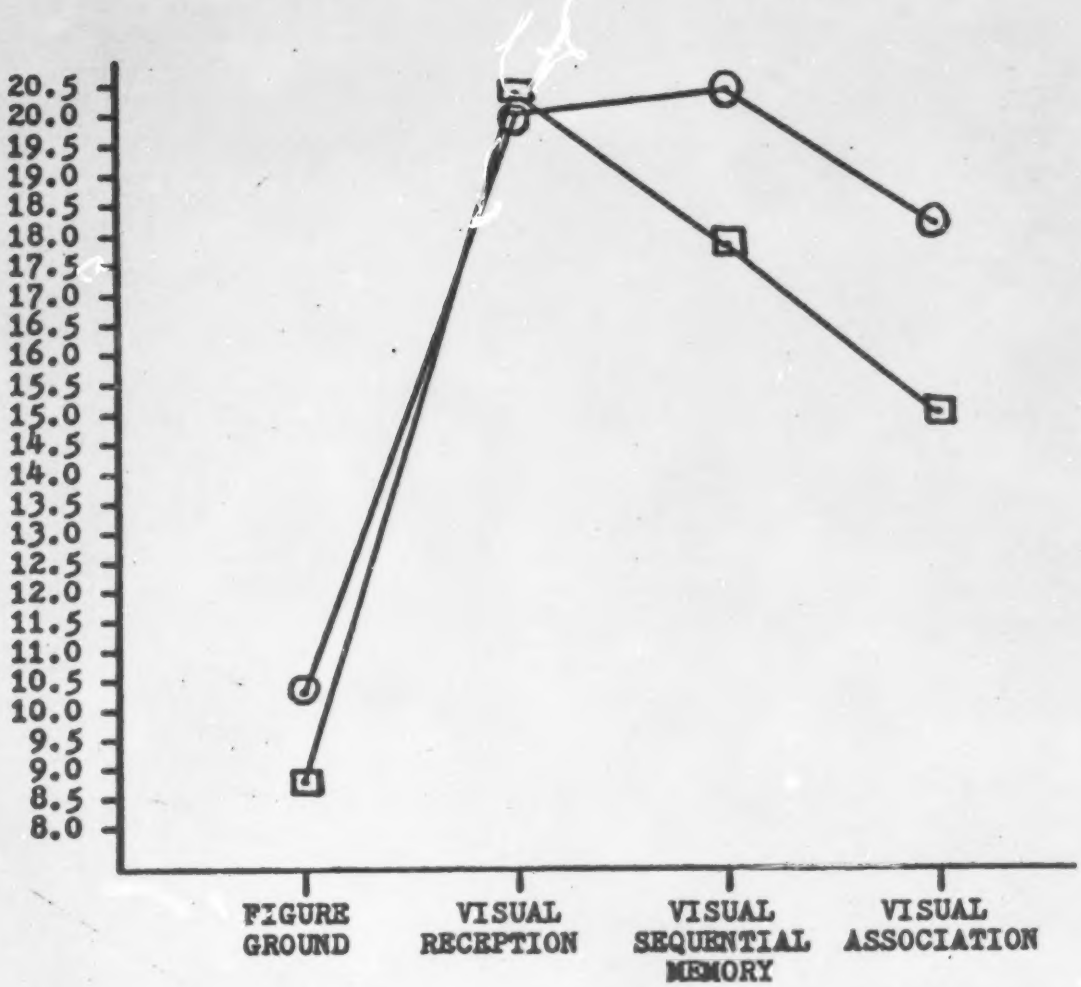
	MEAN SQUARE	UNIVARIATE F	P	STEP DOWN F	P	STAND. DISC. FUNCTION COEF.
FG	9.62	1.03	0.33	1.03	0.33	-0.67
VR	0.34	0.03	0.87	0.56	0.47	0.87
VSM	24.57	1.41	0.25	1.64	0.22	-0.70
VA	44.84	1.11	0.31	0.51	0.49	-0.45

CORRELATION MATRIX

	FG	VR	VSM	VA
FG	1.000			
VR	0.512	1.000		
VSM	0.174	0.415	1.000	
VA	0.284	0.344	0.217	1.000

Graph 4

MEANS: FACTOR IV, BOUNCE CATCHING FIVE TOTAL



Low Group - O
High Group - □

Table 6

MANOVA and Discriminant Function Analysis for
FACTOR V, BOUNCE CATCHING TEN TOTAL: High vs. Low Groups

FACTOR V: BOUNCE CATCHING TEN TOTAL

MEANS	FG	VR	VSM	VA
High	10.33	21.25	16.42	16.50
Low	10.31	17.69	19.85	18.92
STANDARD DEVIATIONS	FG	VR	VSM	VA
High	4.12	5.72	5.76	5.33
Low	3.73	4.44	3.89	5.14
GROUPS (High-Low)		df	F	P
High N = 12 Low N = 12		4, 20	4.17	< 0.01*

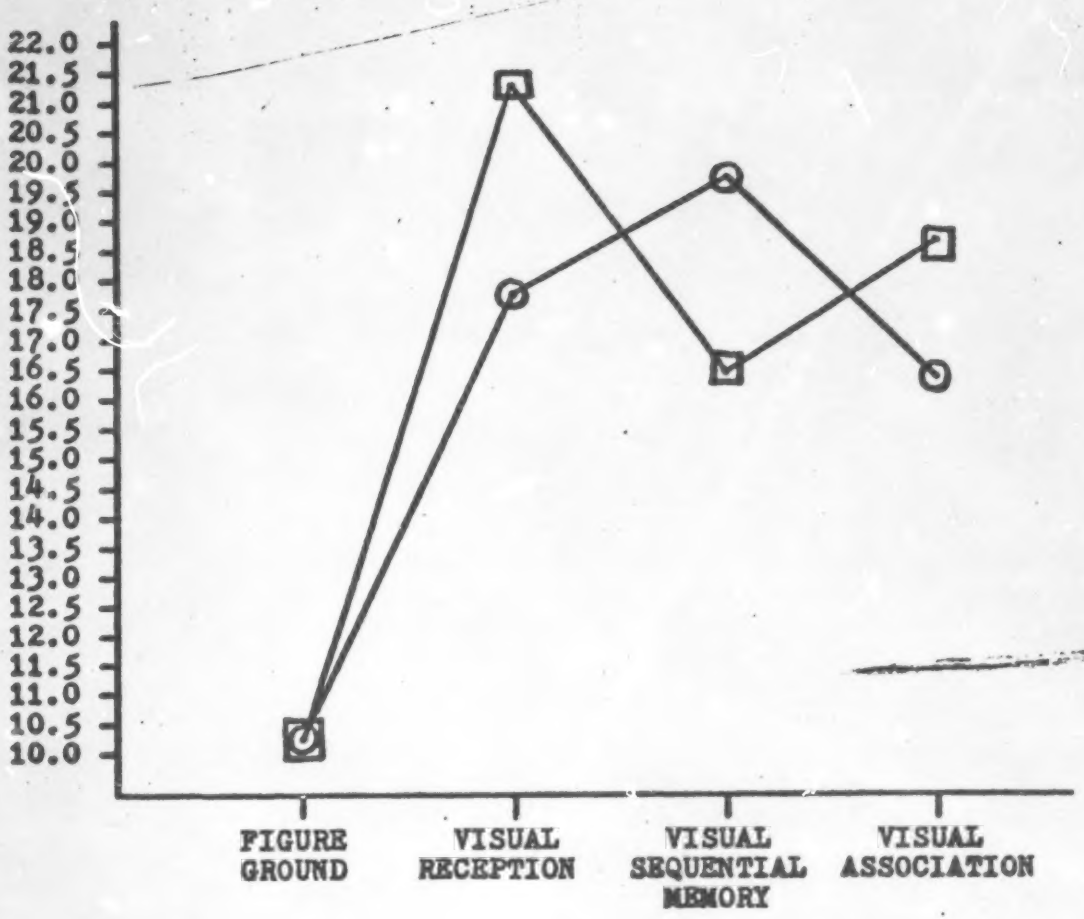
	MEAN SQUARE	UNIVARIATE F	P	STEP DOWN F	P	STAND. DISC. FUNCTION COEF.
FG	0.004	0.0003	0.99	0.0003	0.99	-0.26
VR	78.98	3.04	0.09	3.80	0.06	1.20
VSM	73.39	3.09	0.09	8.87	0.007*	-0.97
VA	36.64	1.34	0.26	2.00	0.17	-0.51

CORRELATION MATRIX

	FG	VR	VSM	VA
FG	1.000			
VR	0.491	1.000		
VSM	0.095	0.515	1.000	
VA	0.452	0.330	0.033	1.000

Graph 5

MEANS: FACTOR V, BOUNCE CATCHING TEN TOTAL



Low Group - ○
High Group - □

zation of stimulus information, little sequencing ability, little neuromuscular integration, little in-depth ocular tracking, etc.

When observing mean trends, the low BC5 group outperformed the high group on visual association, figure ground, and visual sequential memory, with near-equal performance on visual reception. The low BC5 group may not have had a motor program built upon past experience to be able to quickly initiate that program. Although the motor program was weak, the "visual programs," as in the Striking tasks, were more easily initiated. The high BC5 group had strong motor programs but were unable to efficiently perform on the visual measures. Again, experience could be a cause for better performance in either the visual or motor tasks.

When the motor tasks were constructed, a perceptual hierarchy was designed, with the BC tasks being the least demanding of the perceptual system. The fact that BC10 created a significant difference between groups when observing vision variables was not expected. Although Ross's (1961) bounce catch task, which required the child to bounce and catch a ball from below the waist, was the most significantly influenced by vision, the visual functions (binocular acuity and lateral esophoria) were entirely different than the ITPA subtests. Yet, the visual functions were important for successful completion. Auxter (1971), when studying

learning disabled and normal children, found that his ball catch task (from the Iowa-Brace Scale) created a significant difference between groups. The significant difference on the BC10 tasks lended support to Ross's (1961) and Auxter's (1971) results in that SOMETHING in a bounce-catch task, regardless of being self-directed or experimenter-directed, utilized and made demands on the visual perceptual system.

Goodnow (1971) related that proprioception (kinesthesis) formed the base of the perceptual hierarchy. The BC tasks involved direct manipulation of the ball, thus requiring kinesthesis. It seemed logical, then, that these tasks should form the base of the motor task kierarchy. Perhaps it was this basic sensory component - kinesthesis - which determined the significant difference between the high-low groups in BC10. The children were able to bounce the ball, to manipulate the ball, thus utilizing their proprioceptive system. The direct manipulation of the ball (by catching it and bouncing it back to the experimenter) was similar to Jones' (1972) active movement. In his study, Jones (1972) found that active movement enhanced visual perception. In this study, direct manipulation enhanced visual reception, as supported by the standard discriminant function coefficient, which indicated that visual reception was the best predictor of high-low BC10 placement. Visual reception measured the child's ability to understand visual symbols - to observe a symbol; to interpret that information; to select from that

interpretation a structurally similar symbol. The BC10 tasks measured the child's ability to retrieve relevant information; to interpret that information in order to understand where the ball was coming in relation to his body, how fast it was coming, where his hands should be, etc., and then to initiate the motor program to catch the ball. So both tasks, although not task specific, involved an input-interpretation/organization-output schemata.

In both BC tasks, the low group performed better on visual sequential memory. In observing individual scores, it appeared that children exhibiting better BC scores had more ballplaying experience. The high BC group, although better able to catch a bouncing ball, did not display mature sequencing abilities. If the BC tasks form the base of the motor hierarchy, it would be logical that they would require less sequencing ability. Thus, proficient performance in BC tasks was not specifically related to proficient performance in visual sequential memory, for the sequencing requirements were not the same.

Factor VI: Aerial Catching. Mean trends, shown in Table VII and Graph VI, reflected a tendency for the high group to perform better on figure ground and visual reception while near-equal performance was observed on visual sequential memory and visual association. The mean difference for visual reception was the greatest, although the difference was not significant. MANOVA results yielded no

Table 7

MANOVA and Discriminant Function Analysis
for FACTOR VI, AERIAL CATCHING: High vs. Low Groups

FACTOR VI: AERIAL CATCHING

MEANS	FG	VR	VSM	VA
High	11.00	20.60	18.50	16.50
Low	9.91	18.91	18.55	17.10
STANDARD DEVIATIONS	FG	VR	VSM	VA
High	3.74	4.53	3.17	7.11
Low	3.59	4.61	4.34	5.84

GROUPS (High-Low)	df	F	P
High N = 10 Low N = 11	4, 16	0.323	<.86

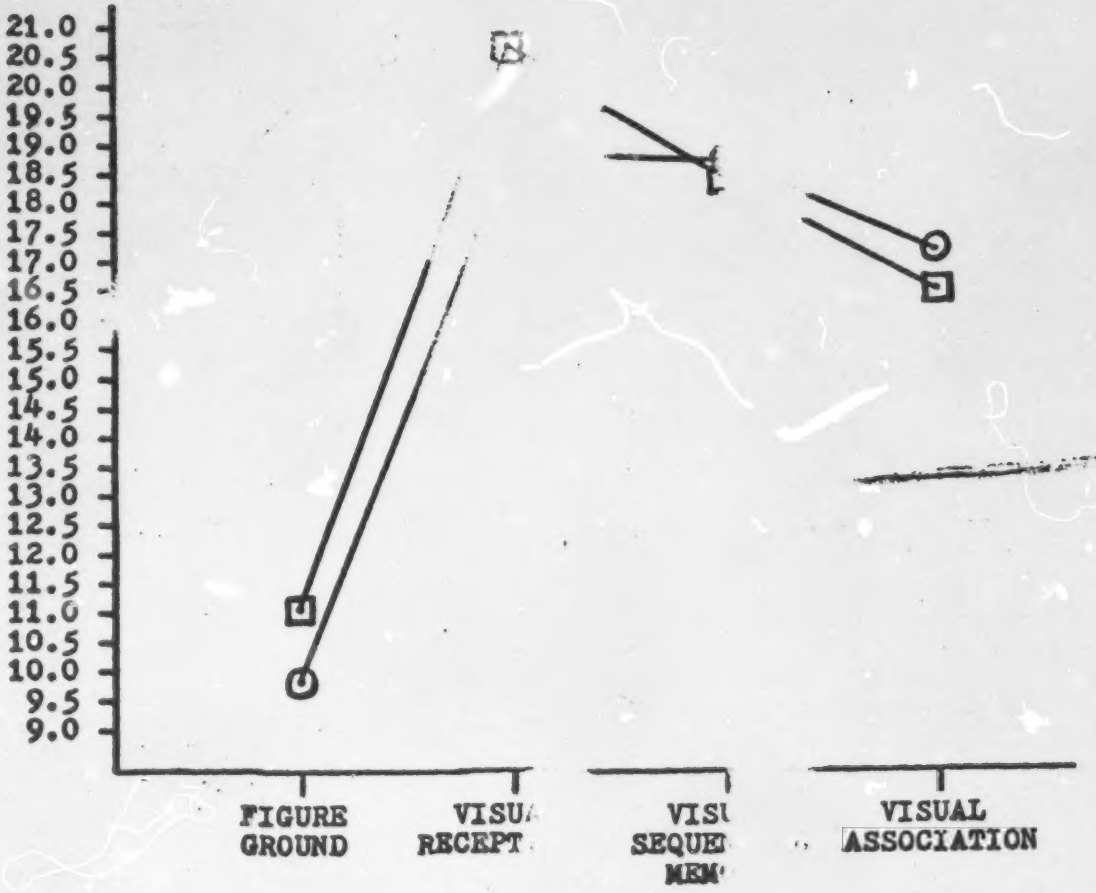
	MEAN SQUARE	UNIVARIATE F	P	STEP DOWN F	P	STAND. DISC. FUNCTION COEF.
FG	6.23	0.46	0.50	0.46	0.50	0.68
VR	14.98	0.72	0.41	0.60	0.45	0.80
VSM	0.01	0.0007	0.98	0.14	0.72	0.23
VA	1.83	0.04	0.83	0.21	0.66	0.47

CORRELATION MATRIX

	FG	VR	VSM	VA
FG	1.000			
VR	0.066	1.000		
VSM	0.006	0.416	1.000	
VA	0.378	0.132	0.272	1.000

G . . 6

MEANS: FACTOR . AERIAL C. ING



Low Group - ○
High Group - □

significant difference between groups ($F = .323$, $p < .86$).

Discussion: Although MANOVA yielded no significant group differences, the mean trends revealed a tendency for the high AC group to perform better on figure ground and visual reception. This was understandable for both visual measures. The distances for the AC task (ten and fifteen feet) were such that the child was required to track the ball more closely, utilizing only information regarding flight of the ball. Because no bounce occurred, the time from when the ball left the experimenter's hands and entered the child's hands decreased, requiring closer ball monitoring, quicker information processing, and program implementation than the BC tasks. Thus, better figure ground perception and information organizing/interpreting abilities were required with the AC tasks. The lack of significant difference between groups was disappointing, but again one could explain that the vision variables did not measure the same types of visual functions that AC did. The two were not task specific. Perhaps if other types of vision variables were measured, the difference would be significant.

General Summary

Statistical analyses of the data revealed the following results:

1. MANOVA yielded no significant differences between high-low groups in Factor I (V), Factor II (SS), Factor III

(MS), Factor IV (BC5), and Factor VI (AC).

2. MANOVA yielded a significant difference between high-low groups ($F = 4.17$, $p < .01$) in the BC1C tasks. Discriminant Function Analysis indicated that visual reception, with a coefficient of 1.20, was the best predictor of group assignment.

The motor tasks were constructed to form a motor hierarchy dependent upon the degree of perceptual sophistication required for successful completion. The BC tasks formed the base, requiring proprioceptive abilities as direct manipulation of the ball was involved. Also included were the following visual-perceptual components: figure ground; low-level ocular tracking; low-level spatial relationship; low-level directionality. It was believed that the BC5 tasks occurred on an almost automatic level for the distance was too short to tax the perceptual system and require neuromuscular integration. The ten-foot distance, however, was great enough that more neuromuscular integration was required for task completion. If unsuccessful completion occurred, the problem was due to immature neuromuscular and intersensory communication, with the inability to quickly process and integrate incoming information into a motor plan.

The lack of significant differences between the motor tasks of AC, SS, and MS, when looking at the vision variables, could be due to the following reasons:

1. There was a lack of task specificity; generaliza-

tion of a SIT-AND-SEE task can not be made to a MOVE-AND-SEE task.

2. There were poorly constructed motor tasks: distances were too short, therefore not taxing the perceptual system.
3. Five-year-olds have not refined their neuromuscular intersensory systems enough to successfully complete the motor tasks.
4. There was a learning effect on the easier, less demanding tasks (particularly BC5 and SS).

It was interesting to note that, in three of the five motor factors, the low group outperformed the high group on visual sequential memory, although only one factor (BC10) yielded a significant difference between groups. Why would children who performed poorly on motor tasks perform well on visual sequential memory as measured by the ITPA? Did the motor tasks utilize visual sequential memory for successful completion in only the BC10 task? Can visual sequential memory be measured by the motor tasks? The answers to these questions would employ further research.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Statement of the Problem

The purpose of this study was to determine if five-year-old children displaying high or low ability to process visual information exhibited the same high-low ability in proficiency of motor tasks which were dependent upon visual information for successful completion.

Review of Methodology

The subjects in this study consisted of 40 five-year-old children (26 girls and 14 boys). Only those children meeting public school requirements for entrance into kindergarten participated in the study. All children were required to pass a visual acuity screening in order to participate.

The data were collected in two areas: movement and vision. The motor tasks included bounce catching, aerial catching, stationary striking, moving striking, and motor sequential memory. The vision tasks included the visual subtests from the Illinois Test of Psycholinguistic Abilities and the Ayres Figure Ground Test.

Statistical Treatment of Data

Data analyses consisted of a principal component factor analysis which was conducted to identify common factors and reduce the dependent variable list. Using the identified factors from the factor analysis and their components, the children were assigned to a High or Low Group for each of the six factors. A series of MANOVAs and discriminant function analyses were conducted to determine significant differences between high-low groups.

Factor Analysis

The factor analysis identified the following six factors: I. Vision, which included visual reception, visual association, visual sequential memory, and figure ground. II. Stationary Striking, which included all striking tasks utilizing the seven and nine-inch balls. III. Moving Striking, which included the striking tasks utilizing the five-inch ball from fifteen feet and the seven-inch ball from both ten and fifteen feet. IV. Aerial Catching, which included catching tasks utilizing the seven and nine-inch balls from ten feet and the nine-inch ball from five feet. V. Bounce Catching Five, which included all bounce-catch tasks from the five-foot distance. VI. Bounce Catching Ten, which included all bounce-catch tasks from the ten-foot distance.

The tasks which loaded on each factor were logical

as all motor tasks grouped together and all vision tasks grouped together. This indicated that the tasks were tapping similar processes. The total score from each motor factor yielded the highest loading and was selected as a dependent variable for the multivariate analysis. The Bounce Catching tasks loaded on different factors according to distance. It was concluded that the Bounce-Catch Five task was more automatic, requiring little perceptual sophistication while the Bounce-Catch Ten tasks required a higher level of perceptual abilities including tracking, figure ground, spatial (body) awareness, and sequencing ability. (Note: The Biopter, Ocular Pursuit, and Closure scores were not included in the factor analysis.)

MANOVA

In an effort to determine if children who performed well on tests of visual proficiency also performed well on motor tasks dependent upon vision for successful completion, a series of MANOVAs were run for each high-low group. No significant difference was found between the high-low visual groups on the various motor tasks. This was understandable as the vision tasks were sit-down standardized tests requiring no active or gross motor movement while the motor tasks, by their very nature, required active participation. The transfer of the visual test components could not be made to the motor tasks. Task specificity was apparent.

In determining differences between the high-low motor groups, using the vision scores as dependent variables, only one significant difference was found. The Bounce-Catch Ten task significantly discriminated High-Low Vision Group performance. It was concluded that the Bounce-Catch Ten task required a perceptual sophistication not required by the other tasks as the child was required to locate and discriminate the ball from its background and to be aware enough of his body to manipulate it in order to catch the ball. Poorly discriminating motor tasks, believed to be the cause for a lack of significant group differences, possibly were due to the following reasons:

1. The response was automatic, as in the Bounce-Catch Five task. Therefore, little processing time was required, which was a lower level of perceptual sophistication.
2. The ball was thrown directly to the child, as in the Aerial Catching task. Little active movement, processing time, and motor programming was required from the child.
3. The ball was bounced directly to the child, as in the Bounce-Catch Five. The distance was too short to require perceptual organization from the child.
4. The ball was thrown directly to the bat in the Moving Striking tasks, again requiring little

perceptual organization from the child.

Conclusions

Based upon statistical treatment of the data, the following conclusions were made:

1. Similar processes were tapped by the vision tasks and by the motor tasks as all vision tasks loaded together and all motor tasks loaded together.
2. No significant differences were found between high-low vision groups on the various motor tasks, indicating that no relationship existed between visual processes (as measured by the ITPA) and motor tasks requiring vision for successful completion. The high vision group did not necessarily perform better on the motor tasks.
3. A significant difference was found between high-low Bounce-Catch Ten groups on the various visual tasks. The high Bounce-Catch Ten group performed significantly better on the vision tasks than the low Bounce-Catch Ten group.

Recommendations

Based upon the conclusions, further research could be

initiated into the following areas:

1. The Bounce-Catch Ten task could be investigated in efforts to determine which visual perceptual components discriminate high-low groups of five-year-old children.
2. Visual perceptual and motor training programs could be implemented in order to determine if training in the motor realm increased visual perceptual components. This would also be interesting as a longitudinal study with Learning Disabled children in efforts to improve academic skills.
3. This study could be replicated using a higher number of children in an effort to determine high-low group differences.

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APPENDIXES

APPENDIX A

STANDARDIZED DIRECTIONS AND PROCEDURES TITMUS BIOPTER

Materials Required: Biopter
Kindergarten and elementary cards
Score sheet
Pencil
Index cards for pretest

The child sits beside E. A pretest is first administered for knowledge of: 1) the alphabet from A through E; 2) the symbols of a star, circle, triangle, square, and cross; and, 3) the numbers one through eight. An index card is presented to S, with E saying "What is this?" All items are presented on a card. If the child fails to identify any of the alphabet, the figures used on a Snellen visual test (the lazy E) are taught and this test is used for acuity.

As S peers through the Biopter for test one, vertical phoria, E says "Do you see the hand drawing the line? Through which figure does the line go? Is it going through the circle, or the triangle, or the star?" Further questions may be asked to assure understanding of the child.

The test booklet, sitting on an illuminated screen, is turned for test two (lateral phoria, far) with E saying "Do you see the paint brush? Where does the paint brush stop?" Colors may also be used to ensure the correct answer.

The booklet is turned to test three (central fusion, far) with E saying "How many boxes do you see? Count them."

In test four (acuity) the child is asked to read a series of letters posted on road signs. If the child does not recognize letters, the Snellen test is given (located in the kindergarten booklet).

The first stereoptic test (test five) is directed by "Do you see the little boy running? In line A (E points), which little boy is winning - he is closer to you. What number is on his shirt? In line B, which little boy is winning?" etc. The second stereoptic test is directed by "In line A (E points), which number looks like he is winning the race?" etc.

Directions for test seven (lateral phoria, near) and test eight (central fusion, near) are the same used for tests two and three.

Approximate testing time is eight minutes.

The standardized score sheet (see next page) is used for scoring. Scores falling within the shaded areas indicate ocular insufficiency.

APPENDIX B

Form T-12

BIOPTOR VISION TESTS

No._____

Name _____ Date _____

Address _____ Age _____

Sex: M ☐ F ☐

Occupation _____

Glasses Worn: No ☐ Always ☐ Near Only ☐ Far Only ☐ Multi-Focal ☐ Other _____

Difficulty with Vision: No ☐ Yes ☐ Last Exam by Doctor _____

Comments _____

FAR POINT TESTS 0

Test No.		Low Score						High Score
1	Vertical Phoria	R. Hyper						
		L. Hyper						
2	Lateral Phoria	Over CONVERGENCE Under	1 / 15	2 / 14	3 / 13	4 / 12	5 / 11	6 / 10	7 / 9	8
3	Central Fusion	Two		Four Far Apart		Four Close Together		Four Then Three		Three Boxes
4	Acuity Left		1	2	3	4	5	6		
			ECDBF	TPCDB	CEZFL	EPCFZ	TZOLF	TCLDZ		
	Both		LDZTC	OETFL	DZBOP	LPTOB	ELTDC	OFLCT		
	Right		TPEOB	DFZDL	TCFBO	ELDTF	DCZOE	DZEOF		
5	Stereo	L-R only	Forward Runner			A 2	B 5	C 3		
5a	Stereo	L-R only	A 4	B 2	C 5	D 3	E 4	F 2		
6	Color	A 8	B 15	C 5	D 35	4 out of 6 All Correct				

NEAR POINT 10

7	Lateral Phoria	Over CONVERGENCE Under	1 / 15	2 / 14	3 / 13	4 / 12	5 / 11	6 / 10	7 / 9	8
8	Central Fusion	Two		Four Far Apart		Four Close Together		Four Then Three		Three Boxes
9	Acuity Left		1	2	3	4	5	6		
			[illegible]	[illegible]	[illegible]	LPCFZ	DCELT	LDZOF		
	Both		[illegible]	[illegible]	[illegible]	DTFOP	LFZOE	LCTDZ		
	Right		[illegible]	[illegible]	[illegible]	ELTOB	TZODC	EOFTC		

APPFNDIX C

STANDARDIZED DIRECTIONS AND PROCEDURES PURDUE MODIFIED OCULAR PURSUIT

Materials needed: Penlight
Disney characters
Score sheet
Pencil

The child is seated facing E. E asks S to select a Disney character for the next game. After placing the character on the penlight, E says "I want you to watch (Mickey) as I move him. I will move him up and down, sideways, and in other different directions (demonstrating). Be sure to follow (Mickey) with only your eyes. Do not move your head - only your eyes."

The penlight is held about twenty inches directly in front of S's face, at eye level. The penlight is moved up and down, diagonally right and left, circularly, and toward and away from the nose. Both binocular and momocular tests are administered.

To score a pass, the child must perform with smooth, even-following movements or with minimal jerkiness or hesitation. To score a failure, the child must perform with uneven, jerky movements, inability to follow the target, loss of the target, or inability to follow the target without moving the head, or lack of parallelism between the two eyes. The score was recorded on the back of the Biopter score sheet.

APPENDIX D

STANDARDIZED DIRECTIONS AND PROCEDURES AYRES FIGURE GROUND TEST

Materials required: Ayres standardized manual
Booklet containing standards
Stopwatch
Score sheet
Pencil

The child is seated at a desk opposite E. E opens the standard booklet, saying "Three of these pictures (pointing) are up here (pointing). Which three are they?" Two plates are demonstrations, with corrections and further explanation permitted. The test is continued with S observing each plate and selecting his choices within one minute. Testing time is approximately ten minutes.

Standardized scoring procedures are followed, with the score being the total correct choices made before three consecutive failures are made.

APPENDIX E

AYRES FIGURE GROUND TEST: SCORE SHEET

Student's number ↘

Plate number ↘					
1.	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
2.	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
3.	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
4.	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
5.	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
6.	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
7.	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
8.	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
9.	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
10.	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
11.	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
12.	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
13.	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
14.	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
15.	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
16.	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3

Three choices must be made for each plate. As S identifies an object, E crosses out 1 (/); the second object identified results in /; while the third object identified results in /. Score is the total number of correct responses or identification. Thus, E needs only count the slash marks (3) for the score.

APPENDIX F

STANDARDIZED DIRECTIONS AND PROCEDURES ITPA VISUAL SUBTESTS

Materials required:
- ITPA examiners manual
- Visual association booklet
- Visual reception booklet
- Tray, chips, booklet for visual sequential memory
- Stopwatch
- Score sheet
- Pencil

The child is seated facing E. All directions are standardized and located in the Examiner's Manual. Approximate testing time is forty-five minutes. Scoring procedures are standardized, with the score for each test being the total number of correct responses before two or three consecutive failures (depending on the test).

APPENDIX G

ITPA VISUAL SUBTESTS: SCORE SHEET
(adapted from standardized score sheet)

Visual Reception (3 consecutive failures)

demo a. $\frac{4}{3}\frac{1}{2}$	$6.\frac{4}{3}\frac{1}{2}$	$11.\frac{4}{3}\frac{1}{2}$	$18.\frac{4}{3}\frac{1}{2}$	$25.\frac{4}{3}\frac{1}{2}$	$32.\frac{4}{3}\frac{1}{2}$
demo b. $\frac{4}{3}\frac{1}{2}$	$7.\frac{4}{3}\frac{1}{2}$	$12.\frac{4}{3}\frac{1}{2}$	$19.\frac{4}{3}\frac{1}{2}$	$26.\frac{4}{3}\frac{1}{2}$	$33.\frac{4}{3}\frac{1}{2}$
$1.\ \frac{4}{3}\frac{1}{2}$	$8.\frac{4}{3}\frac{1}{2}$	$13.\frac{4}{3}\frac{1}{2}$	$20.\frac{4}{3}\frac{1}{2}$	$27.\frac{4}{3}\frac{1}{2}$	$34.\frac{4}{3}\frac{1}{2}$
$2.\ \frac{4}{3}\frac{1}{2}$	$9.\frac{4}{3}\frac{1}{2}$	$14.\frac{4}{3}\frac{1}{2}$	$21.\frac{4}{3}\frac{1}{2}$	$28.\frac{4}{3}\frac{1}{2}$	$35.\frac{4}{3}\frac{1}{2}$
$3.\ \frac{4}{3}\frac{1}{2}$	$10.\frac{4}{3}\frac{1}{2}$	$15.\frac{4}{3}\frac{1}{2}$	$22.\frac{4}{3}\frac{1}{2}$	$29.\frac{4}{3}\frac{1}{2}$	$36.\frac{4}{3}\frac{1}{2}$
$4.\ \frac{4}{3}\frac{1}{2}$	demo a. $\frac{4}{3}\frac{1}{2}$	$16.\frac{4}{3}\frac{1}{2}$	$23.\frac{4}{3}\frac{1}{2}$	$30.\frac{4}{3}\frac{1}{2}$	$37.\frac{4}{3}\frac{1}{2}$
$5.\ \frac{4}{3}\frac{1}{2}$	demo b. $\frac{4}{3}\frac{1}{2}$	$17.\frac{4}{3}\frac{1}{2}$	$24.\frac{4}{3}\frac{1}{2}$	$31.\frac{4}{3}\frac{1}{2}$	$38.\frac{4}{3}\frac{1}{2}$

Sequential Memory (2 consecutive failures)

1st	2nd		1st	2nd		1st	2nd		1st	2nd		1st	2nd
demo 1													
___	___	6.	___	___	11.	___	___	16.	___	___	21.	___	___
1.	___	7.	___	___	12.	___	___	17.	___	___	22.	___	___
2.	___	8.	___	___	13.	___	___	18.	___	___	23.	___	___
3.	___	9.	___	___	14.	___	___	19.	___	___	24.	___	___
demo 2													
___	___	10.	___	___	15.	___	___	20.	___	___	25.	___	___
4.	___												
5.	___												

Line indicates correct responses.

Visual Association (2 consecutive failures)

demo a. 3 4 2 1	6. 3 4 2 1	13. 3 4 2 1	20. 3 4 2 1	25. 3 4 2 1	32. 3 4 2 1
			demo		
b. 3 4 2 1	7. 3 4 2 1	14. 3 4 2 1	a. 3 4 2 1	26. 3 4 2 1	33. 3 4 2 1
1. 3 4 2 1	8. 3 4 2 1	15. 3 4 2 1	b. 3 4 2 1	27. 3 4 2 1	34. 3 4 2 1
2. 3 4 2 1	9. 3 4 2 1	16. 3 4 2 1	21. 3 4 2 1	28. 3 4 2 1	35. 3 4 2 1
3. 3 4 2 1	10. 3 4 2 1	17. 3 4 2 1	22. 3 4 2 1	29. 3 4 2 1	36. 3 4 2 1
4. 3 4 2 1	11. 3 4 2 1	18. 3 4 2 1	23. 3 4 2 1	30. 3 4 2 1	37. 3 4 2 1
5. 3 4 2 1	12. 3 4 2 1	19. 3 4 2 1	24. 3 4 2 1	31. 3 4 2 1	38. 3 4 2 1

Lines indicate correct responses.

APPENDIX H

BALL-CATCHING SEQUENCE

Materials required: Seven and nine inch playground balls
Markers
Tape measure
Score sheet
Pencil

E marks five-foot and ten-foot distances with markers. When the child enters the testing area, E says "See if you can bounce the ball to yourself, like this." E demonstrates the ball bouncing, to self, task using nine-inch ball. "See if you can bounce the ball ten times. Ready? Go."

For the next task (BC95), E says "Now I want you to stand behind this line (placing child). I am going to bounce the ball to you from this line. (E stands behind the five-foot line). The ball can only bounce once, so watch the ball. Keep your feet behind the line. See if you can catch the ball. Ready?"

One practice is given, with further explanation if necessary. E bounces the nine-inch ball ten times, recording the number of successful catches.

E then says "Catch the ball from this far,"(standing behind the ten-foot line). "Catch the ball after it bounces one time."

The same directions are repeated with the seven-inch ball from distances of five and ten feet. Total testing time is approximately twenty minutes. The score is the total

number of successful catches in ten trials. All balls are bounced half-the-distance to S. Any ball not bouncing half-the-distance to S is excluded as a trial.

APPENDIX I

STANDARDIZED DIRECTIONS AND PROCEDURES
STRIKING SEQUENCE

Materials required: Five-inch sponge ball
Seven-inch playground ball
Adjustable T-ball stand
Plastic bat
Markers
Tape measure
Score sheet
Pencil

Stationary Striking Tasks

E adjusts the T-ball stand to the umbilical height of S. Instructions are given for batting, with E saying "We are going to hit some balls with this bat. First, let's learn how to hold the bat." E stands behind S, showing S hand placement on the bat and body placement with the stand.

The seven-inch ball is placed on the stand. Each child is permitted three practice trials, with further corrections and/or explanations given at this time. Ten trials are given, with E saying "See how many times you can hit the ball off the stand. You get ten tries. Ready? Go."

Upon completion of the trials, the five-inch ball is placed on the stand. Following the same directions, the child hits the ball from the stand. Approximate testing time is ten minutes. The score is the total number of successful hits in ten trials. A hit is constituted as any contact of the ball with the bat, regardless of the distance travelled by the ball. If the child hits the stand rather

than the ball, the hit is unsuccessful. If the child hits the stand and the ball simultaneously, the hit is successful.

Moving Striking Tasks

The child is told: "Try to hit the ball when I throw it. Stand here (placing child) with your feet behind this line. I am going to stand here and toss the ball to you. See if you can hit the ball with the bat. Ready?"

E, standing ten feet from S, tosses the seven-inch ball. An underhand toss with mild force is used. If E executes a pitch which does not reach the child, that pitch is excluded. Upon completion of ten trials, E records the score and moves to the fifteen foot line. E then tosses the seven-inch ball ten times, using the same directions.

The same procedure is followed with the five-inch ball from distances of ten and fifteen feet. Approximate testing time is thirty minutes. The score is the total number of successful hits in ten trials.

APPENDIX J

STANDARDIZED DIRECTIONS AND PROCEDURES VISUAL MOTOR SEQUENTIAL MEMORY TEST

Materials required: Task sheet
Score sheet
Pencil

The child stands facing E. E says "I am going to do some moving with my body. Watch me, and then do exactly as I do." E then performs the first task. After S watches, he performs the task as he remembers it. A second trial is given if the child fails on the first trial. Ten tasks are presented. Approximate testing time is ten minutes. The score is the total number of successful tasks perform .

APPENDIX K

VISUAL SEQUENTIAL MEMORY TASKS

Points		Tasks
1	1.	take one step forward (transfer of weight from one foot to other)
1	2.	take one step backward (transfer of weight from one foot to other)
3	3.	take two steps forward, then jump with both feet (both feet must leave the floor)
3	4.	take two steps backward, then jump with both feet (both feet must leave the floor)
4	5.	take two steps forward, clap, then jump (both feet must leave the floor)
4	6.	take two steps forward, then jump two times (both feet must leave the floor)
5	7.	take two steps forward, clap once, turn around (360°), jump once
6	8.	take two steps backward, turn (180°) facing backward, jump once, turn (180°) facing forward, jump once
6	9.	turn one complete circle while clapping, jump two steps forward, jump two steps backward
9	10.	step-close-step (sideway) to one side, two jumps backward, turn around completely, step-close-step to other side, two jumps forward
42 total points		

APPENDIX L

MOTOR PERFORMANCE TESTS: SCORE SHEET

BOUNCE CATCHING

1. ____/ 10 (self)
2. ____/ 10 (9"-5)
3. ____/ 10 (9"-10)
4. ____/ 10 (7"-5)
5. ____/ 10 (7"-10)

STATIONARY STRIKING

1. ____/ 10 (7")
2. ____/ 10 (5")

AERIAL CATCHING

1. ____/ 10 (9"-5)
2. ____/ 10 (9"-10)
3. ____/ 10 (7"-5)
4. ____/ 10 (7"-10)

MOVING STRIKING

1. ____/ 10 (7"-10)
2. ____/ 10 (7"-15)
3. ____/ 10 (5"-10)
4. ____/ 10 (5"-15)

SEQUENTIAL MEMORY

	trial 1	trial 2		trial 1	trial 2
1.			6.		
2.			7.		
3.			8.		
4.			9.		
5.			10.		

APPENDIX M

SUBJECT PERMISSION SLIP

Dear Parent,

I am a Master's Degree Candidate at Kent State University in Health and Physical Education. A thesis is included as part of my requirements for graduation. My topic involves five-year-old children and their ability to perform certain catching and striking tasks. Your child's nursery school has agreed to cooperate with me for which I am extremely appreciable. If you would like your child to participate in this study, please complete the permission slip below and return to your child's teacher. The attached paper is a more detailed description of the study. Please note that your child's name will not be used, but rather only the scores he obtains on the test items. If you have any questions pertaining to this study, please feel free to contact me.

Thank you for your cooperation,

Sandee Skovran
Division of HPERA
Kent State University
672-2990 or 872-1883

(Name of child)_____ has my permission to participate in a study of striking and catching skills in five-year-old children.

_____
(Parent's Signature)

Dear Parent,

This is a more detailed description of the study being conducted by Sandee Skovran to complete requirements for a Master's Degree at Kent State University. The study is an investigation of visual information processing and visual motor proficiency. In this study, the children will be asked to complete the following tasks:

1. Catch a five-inch playground ball which is bounced by the examiner from distances of five and ten feet
2. Catch a five-inch playground ball which is tossed by the examiner from distances of five and ten feet
3. From a T-ball stand, hit a nerf ball and a seven-inch ball with a large plastic bat
4. Hit the nerf ball and the seven-inch ball, after being tossed by the examiner from distances of five and ten feet, with the large plastic bat

In addition, the visual factors of acuity, depth perception, convergence and divergence, and lateral and vertical phoria will be measured by the Titmus Biopter, which is a table device through which the child looks. The standardized tests will measure figure-ground perception(Ayres Figure Ground Test) and visual association, visual reception, and visual sequential memory (Illinois Test of Psycholinguistic Abilities). The possibility of injury, such as being hit by a ball or plastic bat, is minimal as the testing sections are structured so as to prohibit injury, with the examiner working on a one-to-one basis with the children. We hope

to make this a pleasant and enjoyable experience for the children.

The results of this study will be of interest to physical educators, psychologists, neurologists, and other professionals in the area of motor learning.

APPENDIX N

ASSIGNMENT OF HIGH-LOW GROUPS
FACTOR I: VISION

FG		VR		VSM		VA	
Score	ID	Score	ID	Score	ID	Score	ID
18	32	35	32	29	7	26	4
17	27,13	29		28		25	9,27
16	40	28		27		24	25
15	22	27	1,17,22 40	26	31,36	23	34,36,40
14		26		25	40	22	8,15,16 22
13	2,14,20 34,35	25		24		21	11
12	4,8,9,15	24	4,36	23		20	6,7
11		23	6,18,30 35	22		19	1,14,32
10	6,11,12 16,17,23 24,29,33	22	7,11	21	1,3,28	18	5,35
9	26,30,31 36	21	2,12,34 31	20	11,15,24 26, 30	17	12,13
8	1,7,10 19	20	9,15	19	4,9,13 17,20,25 33,34,37	16	10,17,19 37
7	5,18	19	5,27,29	18	14,21,22 35	15	31
6	3,25,28 38,39	18	37,39	17	18,27,32	14	20,33,39
5	21	17	8,20,23	16	2,5	13	28,29
4	37	16	10	15	8	12	
		15	3,14,21 26,33,38	14	6,12,23	11	24
		14	13,19,25 28	13	10,16,29 39	10	21,30
		13		12		9	2,18,38
		12	16,24	11	38	8	
				2	19	7	3,23
						6	26

High: (N=11) 40,22,36,4,32,34,27,9,11,15,35

Low: (N=10) 21,3,26,38,39,23,10,28,24,29

APPENDIX O

ASSIGNMENT OF HIGH-LOW GROUPS
FACTOR II: STATIONARY STRIKING

STATIONARY STRIKING TOTAL SCORES

Score	ID
20	6,35,21,37,31,39,32,40
19	7,22,12,33,13,17,20,34
18	11,14,15,16,23,25,36
17	8,10,38
16	5,26,30,18,28
15	2,27,9,29
14	4,19
13	
12	24
11	3
10	
9	
8	1

High: (N=16) 6,21,31,32,35,37,39,40,7,12,13,17,20,22,33,34

Low: (N=14) 1,3,24,19,4,2,9,27,29,5,26,30,18,28

APPENDIX P

ASSIGNMENT OF HIGH-LOW GROUPS
FACTOR III: MOVING STRIKING

MOVING STRIKING TOTAL SCORES

Score	ID	Score	ID
30	12	16	16,20
29	4	15	34,22,21
28		14	36,18
27	14,37	13	9,31
26	25,40,32	12	
25	6,11,19,30,29	11	2
24	15,17	10	7,1
23		9	33
22	8,23,13,26	8	35
21	38,10,27,23	7	
20		6	
19		5	3
18	28	4	5
17	39		

High: (N=14) 12,4,37,25,40,32,6,19,11,30,15,17,29,14

Low: (N=14) 5,3,35,33,7,1,2,9,31,36,18,34,22,21

APPENDIX Q

ASSIGNMENT OF HIGH-LOW GROUPS
FACTOR IV: BOUNCE CATCHING FIVE

BOUNCE CATCHING FIVE TOTAL SCORE

Score	ID
20	4,12,23,30,31,37,39
19	1,3,6,8,10,13,17,19,22,27,32, 33,35
18	2,14,15,16,21,24,28
17	29,38
16	36
15	5,7,9,11,25,34,40
14	26
13	
12	20
11	
10	
9	
8	18

High: (N=7) 4,12,23,30,31,37,39

Low: (N=10) 18,20,26,5,34,40,7,9,11,25

APPENDIX R

ASSIGNMENT OF HIGH-LOW GROUPS
FACTOR V: BOUNCE CATCHING TEN

BOUNCE CATCHING TEN TOTAL SCORE

Score	ID
20	4,17,19,23,27,37,39
19	10,30,31,32,35
18	1,22,38
17	2,6,15,18,36,21,24,26,29
16	8,11,12,13
15	
14	5,9,14,28,40
13	25,33
12	16,20
11	
10	34,7

High: (N=12) 4,17,19,23,27,37,39,10,30,31,32,35

Low: (N=12) 7,20,16,33,25,3,5,9,14,28,34,40

APPENDIX S

ASSIGNMENT OF HIGH-LOW GROUPS
FACTOR VI: AERIAL CATCHING

AERIAL CATCHING TOTAL SCORE

Score	ID	Score	ID
40	4,23	29	
39		28	
38	12,37	27	3,28,38
37	27,40	26	6,9
36	14,17,30	25	22
35	26	24	33,35
34	10,36	23	5
33	24,31	22	13,15,25,29
32	11,32,39	21	34
31	20	20	1,7,16,18
30	8,19	19	2,21

High: (N=10) 4,23,12,37,40,14,17,30,26

Low: (N=11) 1,2,21,7,16,18,34,13,15,25,29

APPENDIX T

TOTAL VARIABLE CORRELATION MATRIX

	FG	VR	VSM	VA	BCT	ACT	SST	MST	MSM
FG	1.00	0.40	0.09	0.43	-0.04	0.12	0.17	0.22	0.20
VR	0.40	1.00	0.30	0.33	-0.12	0.12	0.15	0.13	0.10
VSM	0.09	0.30	1.00	o.17	-0.29	0.01	0.10	-0.19	0.20
VA	0.43	0.33	0.17	1.00	-0.01	0.00	0.17	0.25	-0.06
BCT	-0.03	-0.12	-0.29	-0.01	1.00	0.28	-0.02	0.30	-0.08
ACT	0.12	0.12	0.01	0.00	0.28	1.00	0.10	0.59	0.06
SST	0.17	0.14	0.10	0.17	-0.02	0.10	1.00	0.25	-0.35
MST	0.22	0.13	-0.19	0.25	0.30	0.59	0.25	1.00	-0.03
MSM	0.20	0.10	0.20	-0.06	-0.08	0.06	-0.35	-0.03	1.00
BCS	0.25	0.02	-0.26	0.11	0.46	0.28	0.12	0.59	0.02
BC59	0.10	-0.07	-0.13	0.1o	0.34	0.20	0.06	0.27	-0.13
BC109	0.03	0.22	-0.28	-0.01	0.47	0.32	0.04	0.30	-0.05
BC57	-0.01	-0.01	-0.23	-0.04	0.43	0.35	-0.05	0.14	-0.09
BC107	-0.03	0.23	-0.30	-0.28	0.30	0.47	-0.13	0.27	-0.09
AC59	0.07	-0.19	-0.04	-0.09	0.09	0.67	0.10	0.39	-0.03
AC109	0.22	0.28	0.06	0.07	0.30	0.89	0.15	0.60	0.20
AC57	0.10	0.10	0.11	0.08	0.10	0.58	0.02	0.12	-0.11
AC107	-0.06	0.07	-0.06	-0.06	0.26	0.87	-0.02	0.53	-0.02
SS5	0.22	0.13	-0.00	0.18	0.02	0.08	0.87	0.11	-0.31
SS7	0.05	0.11	0.18	0.10	-0.05	0.09	0.79	0.33	-0.26
MS105	0.24	0.26	0.01	0.32	0.33	0.62	0.21	0.77	-0.10
MS107	0.23	0.18	-0.09	0.16	0.23	0.46	0.24	0.79	-0.07
MS155	0.12	0.17	-0.32	0.23	0.26	0.40	0.06	0.89	0.02
MS157	0.05	-0.01	-0.21	0.05	0.23	0.47	0.09	0.83	0.17
BC5T	0.06	-0.00	-0.21	0.03	0.44	0.32	0.00	0.22	-0.12
BC10T	-0.00	0.27	-0.34	-0.18	0.45	0.47	-0.06	0.34	-0.09

	BCS	BC59	BC109	BC57	BC107	AC59	AC109	AC57	AC107
FG	0.25	0.10	0.03	-0.01	-0.03	0.07	0.22	0.10	-0.06
VR	0.02	-0.07	0.22	-0.01	0.23	-0.19	0.28	0.10	0.07
VSM	-0.26	-0.13	-0.28	-0.23	-0.30	-0.04	0.06	0.11	-0.06
VA	0.11	0.10	-0.01	-0.04	-0.28	-0.09	0.07	0.08	-0.06
BCT	0.46	0.34	0.47	0.43	0.30	0.09	0.30	0.10	0.26
ACT	0.28	0.20	0.32	0.35	0.47	0.67	0.89	0.58	0.87
SST	0.12	0.06	0.04	-0.05	-0.13	0.10	0.15	0.02	-0.02
MST	0.59	0.27	0.30	0.14	0.27	0.39	0.60	0.12	0.53
MSM	0.02	-0.13	-0.05	-0.09	-0.09	-0.03	0.20	-0.11	-0.02
BCS	1.00	0.47	0.34	0.35	0.30	0.03	0.31	0.16	0.28
BC59	0.47	1.00	0.21	0.63	0.23	0.15	0.15	0.31	0.10
BC109	0.34	0.21	1.00	0.50	0.42	0.02	0.41	0.07	0.30
BC57	0.35	0.63	0.50	1.00	0.45	0.19	0.22	0.51	0.28

TOTAL VARIABLE CORRELATION MATRIX (continued)

	BCS	BC59	BC109	BC57	BC107	AC59	AC109	AC57	AC107
BC107	0.30	0.23	0.42	0.45	1.00	0.35	0.39	0.40	0.36
AC59	0.03	0.15	0.02	0.19	0.35	1.00	0.45	0.34	0.42
AC109	0.31	0.15	0.41	0.22	0.39	0.45	1.00	0.36	0.71
AC57	0.16	0.31	0.07	0.51	0.40	0.34	0.36	1.00	0.40
AC107	0.28	0.10	0.30	0.28	0.36	0.42	0.71	0.40	1.00
SS5	0.19	0.15	0.02	-0.02	-0.06	0.06	0.12	0.11	-0.04
SS7	-0.00	-0.08	0.04	-0.13	-0.17	0.12	0.15	-0.11	0.02
MS105	0.36	0.31	0.31	0.13	0.27	0.54	0.58	0.17	0.50
MS107	0.55	0.11	0.16	0.10	0.33	0.24	0.42	0.13	0.45
MS155	0.48	0.15	0.34	0.05	0.22	0.11	0.48	-0.05	0.42
MS157	0.59	0.17	0.32	0.09	0.25	0.23	0.51	0.11	0.43
BC5T	0.45	0.86	0.43	0.93	0.40	0.19	0.22	0.47	0.23
BC10T	0.38	0.26	0.83	0.56	0.86	0.23	0.47	0.29	0.39

	SS5	SS7	MS105	MS107	MS155	MS157	BC5T	BC10T
FG	0.22	0.05	0.24	0.23	0.12	0.05	0.06	-0.00
VR	0.13	0.11	0.26	0.18	0.17	-0.01	-0.00	0.27
VSM	-0.00	0.18	0.01	-0.09	-0.32	-0.21	-0.21	-0.34
VA	0.18	0.10	0.32	0.16	0.23	0.05	0.03	-0.18
BCT	0.02	-0.05	0.33	0.23	0.26	0.23	0.44	0.45
ACT	0.08	0.09	0.62	0.46	0.40	0.47	0.32	0.47
SST	0.87	0.79	0.21	0.24	0.06	0.09	0.00	-0.06
MST	0.11	0.33	0.77	0.79	0.89	0.83	0.22	0.34
MSM	-0.31	-0.26	-0.10	-0.07	0.02	0.17	-0.12	-0.09
BCS	0.19	-0.00	0.36	0.55	0.48	0.59	0.45	0.38
BC59	0.15	-0.08	0.31	0.11	0.15	0.17	0.86	0.26
BC109	0.02	0.04	0.31	0.16	0.34	0.32	0.43	0.83
BC57	0.02	-0.13	0.13	0.10	0.05	0.09	0.93	0.56
BC107	-0.06	-0.17	0.27	0.33	0.22	0.25	0.40	0.86
AC59	0.06	0.12	0.54	0.24	0.11	0.23	0.19	0.23
AC109	0.12	0.15	0.58	0.42	0.48	0.51	0.22	0.47
AC57	0.11	-0.11	0.17	0.13	-0.05	0.11	0.47	0.29
AC107	-0.04	0.02	0.50	0.45	0.42	0.43	0.23	0.39
SS5	1.00	0.40	0.11	0.12	-0.08	-0.01	0.09	-0.03
SS7	0.40	1.00	0.27	0.32	0.22	0.18	-0.11	-0.08
MS105	0.11	0.27	1.00	0.52	0.55	0.49	0.23	0.35
MS107	0.12	0.32	0.52	1.00	0.66	0.48	0.13	0.30
MS155	-0.08	0.22	0.55	0.66	1.00	0.82	0.11	0.33
MS157	-0.01	0.18	0.49	0.48	0.82	1.00	0.13	0.34
BC5T	0.09	-0.11	0.23	0.13	0.11	0.13	1.00	0.49
BC10T	-0.03	-0.08	0.35	0.30	0.33	0.34	0.49	1.00

APPENDIX U

TOTAL FACTOR ANALYSIS

FACTOR I: V		FACTOR II: SS		FACTOR III: MS	
FG	-0.741	SST	0.942	MST	0.923
VA	-0.704	SS5	0.830	MS155	0.915
VR	-0.691	SS7	0.738	MS157	0.847
VSM	-0.485	MSM	-0.610	MS107	0.708
MSM	-0.287	MS105	0.189	BCS	0.694
MS105	-0.238	MS107	0.185	MS105	0.616
AC109	-0.209	MST	0.154	AC109	0.447
SS5	-0.205	BC59	0.145	AC107	0.416
BC107	-0.181	AC59	0.139	BCT	0.415
AC59	0.171	BC5T	0.112	ACT	0.396
AC57	-0.169	VA	0.111	VSM	-0.379
SST	-0.162	AC57	0.075	BC109	0.340
BCT	0.149	BCS	0.069	BC10T	0.313
BCS	-0.142	BC107	-0.062	BC95	0.246
BC59	-0.139	BC57	0.060	SST	0.205
MS107	-0.137	ACT	0.052	VA	0.195
MST	-0.130	BC109	0.050	BC107	0.193
BC10T	0.127	MS157	-0.049	AC59	0.182
AC107	0.091	FG	0.041	BC5T	0.174
BC5T	-0.071	MS155	-0.040	FG	0.151
MS155	-0.061	VR	0.038	AC57	-0.095
SS7	-0.049	BC107	-0.037	SST	0.093
ACT	-0.047	BCT	0.033	BC57	0.085
MS157	0.028	AC109	0.027	MSM	0.041
BC109	0.027	VSM	0.012	VR	-0.230
BC57	0.017	BC10T	-0.009	SS5	-0.020

FACTOR IV: BC5		FACTOR V: BC10		FACTOR VI: AC	
BC5T	-0.917	BC10T	0.820	ACT	0.866
BC57	-0.843	BC109	0.755	AC59	0.720
BC59	-0.829	BC107	0.633	AC107	0.717
AC57	-0.533	VR	0.534	AC109	0.705
BCT	-0.426	BC57	0.314	AC57	0.577
BCS	-0.389	BCT	0.271	MS105	0.439
SS7	0.339	VSM	-0.231	BC107	0.398
BC10T	-0.313	AC109	0.227	VSM	0.285
BC107	-0.301	AC59	-0.199	MST	0.275
BC109	-0.224	BC5T	0.194	BC10T	0.271
VR	0.220	VA	-0.175	MS107	0.231
VSM	0.212	BC5	0.107	MS157	0.185
ACT	-0.202	MS155	0.104	VA	-0.137
AC59	-0.176	AC107	0.100	BC57	0.132

TOTAL FACTOR ANALYSIS (continued)

FACTOR IV: BC5		FACTOR V: BC10		FACTOR VI: AC	
SST	0.150	ACT	0.093	VR	0.128
MSM	0.131	MSM	-0.070	BCS	-0.112
MS155	0.119	BC59	-0.067	MSM	0.099
AC107	-0.108	MS107	0.065	SS7	0.078
MS105	-0.073	SS7	-0.059	MS155	0.062
MS107	0.059	AC57	0.030	BC59	-0.062
SS5	-0.044	MS105	0.024	BC5T	0.059
AC109	-0.041	SS7	-0.021	BC109	0.044
MS157	0.032	FG	0.016	SST	0.030
FG	-0.027	SS5	0.016	BCT	-0.028
VA	-0.021	MS157	0.015	SS5	-0.019
MST	-0.005	MST	-0.013	FG	0.002